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ICAR

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CMFRI

ANNUAL REPORT 2019

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Indian Council of Agricultural Research
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

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An endangered stingray *Urogymnus polylepis* landed at Digha, Bengal
Photograph by Dr. Swatipriyanka Sen Dash CMFRI

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Contents

Mandate

Monitor and assess the marine fisheries resources of the Indian Exclusive Economic Zone (EEZ) including the impact of climate and anthropogenic activity and develop sustainable marine fishery management plans

Basic and strategic research in mariculture to enhance production

Act as a repository of geospatial information on marine fishery resources and habitats

Consultancy services and human resource development through training, education and extension

Preface

I am proud to present the CMFRI Annual Report in a truncated format for the year 2019 due to its change in the reporting period from a financial one (April to March) to an annual one (January – December). Thus, this report covers the period April to December 2019.

Compared to 2018, marine fish landings during 2019 increased by 2.1% from 3.49 million tonnes to 3.56 million tonnes. In terms of total marine fish landings, Tamil Nadu overtook Gujarat after several years. Emergence of the Red toothed trigger fish (*Odonus niger*) a major resource was unusual with simultaneous reduction in landings of Indian oil sardine and mackerel. Six cyclonic storms in a year along the Indian coast was also an unprecedented climatic phenomenon.

In 2019, marine fish landings was valued at Rs.60,881 crores at landing Centre and Rs.92356 crores at retail Centre. CMFRI prepared and published minimum legal size proposals for resources of Tamil Nadu (113 species) and Maharashtra (58 species). Management plan for marine fisheries of Gujarat, non-detriment findings on silky and thresher sharks of Indian Ocean, policy advisory and guidance for good mussel farming practices, advisories and precautions for jelly fish fishers are some noteworthy outputs.

A National Mariculture Policy 2019 (NMP 2019) was submitted to the Department of Fisheries (DoF) and National Fisheries Development Board (NFDB). A Working Group 3 Report [Fisheries, Aquaculture and Fish Processing] for developing a road map to Blue Economy of India was submitted to the Economic Advisory Council to the Prime Minister (EAC-PM).

Otolith and statolith research in fisheries was used for environmental impact assessment, as well as taxonomic ambiguity resolution. Otoliths were also used to make jewelry.

In the area of marine environment management research, Blue carbon stock of sea grass meadows of Palk Bay was quantified, 3D profile of the blue carbon stock of sediments of the mangroves from Vembanad Lake was analysed, changes in the breeding patterns of three pelagic bird species *viz.*, Sooty tern, Brown Noddy, Great Crusted Tern were recorded at Pitti in Lakshadweep.

In the area of mariculture, CMFRI installed 2608 cages all over the country. First spawning and hatching of *Siganus vermiculatus* was achieved. Micro-nursery hatchery system (down welling and upwelling system) developed at Vizhinjam has yielded 0.2 million seed of green mussel seeds which were supplied to the State Fisheries department for farming. Seed/yolk sac larval production of fishes *viz*., Indian pompano (3.4 lakhs), orange spotted grouper (100,000), *Lethrinus lentjan* (100 lakhs), *Penaeus semisulcatus* (PL15–500 lakhs) and *Sepioteuthis lessoniana* (1950) were produced and distributed to selected beneficiaries and private entrepreneurs for marine cage and coastal pond farming/sea ranching. CMFRI closed the life cycle of one food fish *Siganus vermiculatus* (Rabbit fish) two more marine ornamentals– *Pseudanthias squamipinnis* (Sea goldie or lyretail coralfish) and *Dascyllus melanurus* (Four stripe damselfish). CMFRI also produced designer clowns– Platinum, Snow flake, Picasso, Tear drop; alongwith year round production of other clown fishes such as, Percula clown, Tomato clown, Skunk clown and Maroon clown. A marine ornamental shrimp *Lismata amboinensis* was also bred in captivity. Natural spawning of F1 generation of Indian pompano was achieved in RAS system. For the food fish basket, CMFRI successfully achieved the broodstock development in captivity of marine finfish species viz, *Pomadasys furcatus*, *Acanthopagrus berda, A. latus* and *Lutjanus johnii*.

Continuing our work of marine bioprospecting, a seaweed bioactive-based anti-osteoporetic (AOe) product was developed. Complete mitogenome of the Indian scad, *Decapterus russelli* has been characterized. Genetic population structure of Oceanic white tip shark (*Carcharhinus longimanus*) and Scalloped hammerhead shark, *Sphyrna lewini*–has been characterized using mitochondrial control region markers–lack of genetic differentiation within the Indian coast and significant differentiation between ocean basins. Genetic investigations on Indian Ocean squid, *Uroteuthis duvauceli* indicated the presence of cryptic diversity as three different clades were detected along the Indian coast. Two cryptic sub-species have been documented in the mud spiny lobster *Panulirus polyphagus* using whole mitogenome and partial mitochondrial DNA analysis (COI and control region).

Awareness campaigns were initiated and pamphlets were prepared for the identification *Mytella strigata*, a new invasive mussel species of South American origin reported from Kerala. Two new myxozoan species described were *Myxobolus chanosi* n. sp. and *Auerbachia ignobili* n. sp. respectively. An new Acanthocephalan parasite (*Neochinorhynchus cephali* n. sp.) was described from *Mugil cephalus.* Transcriptome of *E. suratensis* gills, adapted to saline, brackish and freshwater environment was completed.

Phylogenetics studies among *Conus (Pinoconus) catus* revealed exceptional phenotypic plasticity among varying ecosystems of Andaman and Lakshadweep archipelagos without any genetic modifications. Ecological successions–from a coral dominated to anemone dominated reef flats was recorded from the surveys at Agatti atoll.

Under NICRA Project, in collaboration with ISRO-SAC, a mobile application for integration of small wetland (<2.2 Ha) field data into spatial data was developed.

CMFRI published 194 peer reviewed articles, contributed 14 book chapters, 5 books, 10 monograpahs and training manuals each and 80 popular/ technical articles. We also conducted 24 orientation and training programmes each, 10 exhibitions and 3 demonstrations. 10 MoUs were also signed, with State Universities Institutes/ private labs etc.

For the 10th time, CMFRI won Rajarshi Tandon Award instituted by ICAR for the Excellent Official Language activities among the Institutes situated in 'C' Region for the year 2017-2018. CMFRI bagged Rajbhasha Rolling Trophy (1st Position) of Kochi Town Official Language Implementation Committee for the best implementation of Official Language during 2017-18. CMFRI retains overall title in ICAR South Zone Sports Meet (4th time).

CMFRI hosted the third international symposium on Marine Ecosystem: Challenges and Opportunities (MECOS-3), 07-10 January 2020 under the aegis of the Marine Biological Association of India.

Dr. Trilochan Mohapatra, Director General, ICAR during his visit to CMFRI released Cadalmin™ Antihypertensive extract (Cadalmin™ AHe), a nutraceutical product for hypertension on 25th May 2019. An International training programme on Fisheries and Aquaculture was conducted at CMFRI during 15-29 October, 2019 sponsored by African-Asian Rural Development Organization, (AARDO), New Delhi, India for 10 participants from 10 countries was conducted. CMFRI hosted a three-day Buyer-Seller Meet and *Kisan Mela* from 14to 16November 2019 jointly with Swadeshi Science Movement, NABARD and Ernakulam *Krishi Vigyan Kendra* of CMFRI. A National Symposium on Enigmatic Indian Oil Sardine (IOS) was held on 06 Aug 2019 at CMFRI, Kochi to launch a multi-institutional project for forecasting IOS fishery on a regular basis.

Dr. Grinson George, CMFRI was deputed as Senior Program Specialist at SAARC Agriculture Centre, Dhaka and Dr. Mohammed Koya was selected as Vice-President of 16th Working Party on Ecosystems and Bycatch (WPEB16), Indian Ocean Tuna Commission, FAO.

I place on record my sincere appreciation to all staff of CMFRI for their contributions to CMFRI's Achievements and the support extended by the Fisheries Division of ICAR, New Delhi.

Executive Summary

CMFRI had 37 in-house projects, 39 externally funded projects and 13 consultancy projects in operation in the year 2019.

Marine fish landings in India for the year 2019 were estimated as 3.56 million tonnes. It was 2.1% more that the estimate of 2018. After a couple of years, Gujarat was superseded by Tamil Nadu in its marine fish catch. Marine fish catches declined in Gujarat, Maharashtra, Goa, Kerala and Puducherry and increased in Daman and Diu, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha and Bengal. In the ChloRIFFS project spatial distribution of marine fish landings along Gujarat coast was mapped.

In the project on a model for the primary production in Indian coastal waters, it was observed that, apart from upwelling, high precipitation during summer monsoon also contributed to coastal productivity along South Eastern Arabian Sea (SEAS) significantly. The study also proposed scope for a detailed analysis of those specific years with the help of sufficient *in-situ* data especially for the riverine discharge.

State wise nuances in the data of the marine fish landings, biology, policy advisories and stake holder consultations are presented as separate sections titled, Gujarat, Maharashtra, Karnataka and Goa, Kerala and Lakshadweep, Tamil Nadu and Puducherry, Andhra Pradesh, Large Pelagic resources, Bivalve resources, Gastropod resources, Elasmobranchs, Odisha and Bengal and Stake holder consultations. These sections are dealt under the common heading, sustainable management of fishery resources.

In the area of fish genetics and genomics, complete mitogenome of the Indian scad, *Decapterus russelli* has been characterized. Genetic population structure of oceanic white tip shark (*Carcharhinus longimanus*) and scalloped hammerhead shark, *Sphyrna lewini* has been characterized using mitochondrial control region markers revealing a lack of genetic differentiation within the Indian coast and significant differentiation between ocean basins. Genetic investigations on Indian Ocean squid, *Uroteuthis duvauceli* indicated the presence of cryptic diversity as 3 different clades were detected along the Indian coast. Two cryptic sub-species have been documented in the mud spiny lobster *Panulirus polyphagus* using whole mitogenome and partial mitochondrial DNA analysis (COI and control region). Transcriptomic investigations in *P. malabarica* provided insights regarding upregulated and downregulated genes in individuals collected from Ashtamudi and Dharmadam estuaries providing clues regarding influence of environment on expression of genes. Two cryptic subspecies have been documented in the mud spiny lobster *Panulirus polyphagus* using whole mitogenome and partial mitochondrial DNA analysis (COI and control region). Effect of different stocking density, feeding frequency and growth hormone and insulin like growth factor gene expression were correlated with growth performance of orange spotted grouper.

In cell and tissue culture, long-term cultures of mantle epithelial cells of *P. margaritifera* are being maintained in viable state for more than 5 years, first of its kind in invertebrate cell culture research. Long term storage (60 days) of *in-vitro* cultured mantle epithelial cells was achieved using 10% concentrations of glycerol, DMSO as cryoprotectant. The optimum cell viability after cryoprotection in comparison to unfrozen control (without cryoprotectant) was 98% with glycerol and 94 % with DMSO. Induction of nacre on nuclear beads using cryopreserved cells revealed a good brick and mortar pattern, after 60 days of incubation. Genes involved in nacre biomineralization (lustrin, amorphous calcium carbonate binding protein, carbonic anhydrase 1 and mollusc shell framework protein) have been amplified and sent for sequencing. Trials were conducted to analyze the nuclear DNA content of *in-vitro* cultured mantle epithelial cells by flow cytometry to compare the DNA content of epithelial cells from fresh mantle tissue and cultured epithelial cells. Screening of major bioactive compounds from the extract of mantle tissue of *P. fucata* is under progress. Beads were coated with biopolymers such as carrageenan, collagen and chitosan extracted from marine sources. These biopolymer coated beads were subjected to SEM analysis. The beads coated with the combination of collagen and chitosan shows better coating. Scaffolds of different combination of biomaterials were prepared to test the affinity of mantle cells over them.

New species identified through eDNA sequencing needs to be verified by traditional taxonomy. Through spatial analysis, identification of locations and tagging based on interactive GIS Bathymetry and local geological and geographical considerations is carried out. Efforts to convert sampling points to live maps so that it could be overlaid onto Google earth and made available on smartphone is also attempted.

In fish nutrition and feed biotechnology, a protocol was developed production of cotton seed protein concentrate with yield of 24-31% of the raw material. It contained 69-71% protein compared to 42% protein in the cotton seed meal. Fifty percent fish meal could be replaced with cotton seed meal protein concentrate when evaluated in pompano, (*Trachinotus blochii*) feed. Insect protein production with black soldier fly (BSF) using fish waste resulted in the highest biomass and protein content. The lipid content (% DM basis) of larvae varies from 36 – 38%, and a method for defatting of BSF larvae meal was optimized. BSF larvae contain a level of lipids (~35% on DM basis), which causes problems of rancidity and issues with feed formulation and storage. The process optimized lead to production of defatted BSFL was less than 10% on DM basis.

Dietary lysine requirement of silver pompano *(T. blochii)* was estimated as 2.40 to 2.45 % of dry diet (5.71 to 5.83 % of dietary crude protein). Methionine requirement was found to be 1.16 to 1.18 % of dry diet (2.76 to 2.83 % of dietary crude protein). Insulin like growth factor (IGF) gene expression in liver and muscle support the above findings. Mass culture of green alga, *Coelastrella vacuolata* belonging to the family scenedesmaceae was standardized and nutrient profile was characterized. The effect of *C. vacuolata* meal as a fish meal replacer in the diet of Percula clown fish, *Amphiprion percula* was also studied. The results revealed that *Coelastrella* meal can be utilized as a very good natural colour enhancing agent *Coelastrella* meal can replace fish meal at the rate of 10 % of inclusion level to enhance the colour of the fish without affecting the growth.

The fatty acid profile of deep sea lobster *Puerulus sewelli* indicated that high energy fatty acids EPA (10.02% and DHA 11.2%) were the major fatty acids. Higher hypocholesterolemic/ hypercholesterolemic ratio (>2.4) and lower atherogenic (<1.8) and thrombogenicity (<0.3) indices makes lobster an ideal health food. Exploring the commonly available tropical chlorophytan seaweeds as potential nutritional sources, six tropical green seaweeds could be used as a potential health food. The n-3/n-6 ratio of *Ulva lactuca* (~2.14) showed the consumption of this species of seaweed would be ideal for health promotion. C*haetomorpha linum* was found to be rich in calcium, magnesium and phosphorous.

In lobster nutrition, an evaluation of shrimp head waste based feed (from CIFT) and CMFRI feed resulted in poor growth in spiny lobster. Wet feeds were tested for their feeding response time. Fish meat (*Thryssa*) elicited the faster response with longer time for consumption. Clam and squid were consumed faster than fish meat. Crab meat was the least attractive to spiny lobsters.

In the fish health management research project, myxosporeans belonging to eleven genera (*Myxobolus, Ceratomyxa, Myxodavsia, Pseudalatospora, Sphaerospora, Sphaeromyxa, Ellipsomyxa, Auerbachia, Henneguya, Ortholinea* and *Zschokkella)* were recovered. Prevalence varied from 14.6% to 100% with an average prevalence of 52.61%. A new species of myxosporean, *Myxobolus cochinensis* n. sp. was described from *Planiliza macrolepis.* A new species of myxosporean, *Ceratomyxa xanthopteri* n. sp. described from the marine ornamental fish, *Acanthurus xanthopterus*. A detailed study on the various developmental stages of *A. ignobili* n. sp. infecting *Caranx ignobilis* using Fluorescent *in situ* Hybridization (FISH) was conducted with *Auerbachia*-specific probes. Histology indicates that *A. ignobili* n. sp. develops within the hepatic bile ducts and mature myxospores are transported and stored in the gallbladder. The present study clarifies the coelozoic nature of genus *Auerbachia.* A new species of didymozoid trematode, *Nematobothrium ignobili n. sp.* recorded from the peritoneal cavity of *Caranx ignobilis.* This unusually long trematode, measured 400 x 0.421 mm in size. A new species of an acanthocephalan parasite, *Neoechinorhynchus cephali n. sp.* infecting *Mugil cephalus* has been identified and described. Studies carried out to assess the occurrence of parasites in cage farmed, nursery reared and feral fishes at Karwar. *Lates calcarifer* was infected with marine leeches, helminth worms and isopods (*Cymothoa* sp.). *Argulus quadristriatus*, *A. ocellatum* and *Deplictanum* sp., (a monogenean) was reported from *T. blotchii* and *Rachycentron canadum* infection with *Oodinium* species in the skin and gills of aquarium fishes recorded infestations with *Cymothoa* were reported from *R. kanagurta* and *C. ignobilis*. Infection with the larvae of *Echinocephalus overstreeti* and *Caligus* sp. was reported from *Acanthopagrus berda*.

In marine crabs genetic analysis of non-ribosomal peptide synthetase (NRPS) genes in haemolymph microbes was done. NRPS genes from bacterial strains belonging to 5 different species were identified. Marine crab haemolymph microbiota is an unexplored niche to discover novel NRPS genes and natural products. Antioxidant profiles in haemolymph of Asian Green lipped Mussel (*Perna viridis*) were studied to understand the environmental response of antioxidant systems. Results showed that profiles of all studied components namely, GSH, GPx and SOD were influenced to a major extent by the inhabiting conditions.

While quantifying malondialdehyde (MDA) as biochemical marker of oxidative stress, lipid peroxidation was measured in the gills and digestive diverticula of three commercially important bivalve species along the Kerala coast. There is a prevalence of *V. parahemolyticus* and *E. coli* in commercially important marine bivalves along the coast of Kerala which were characterized.

Under the CRP on diagnostics and vaccines, a monovalent vibrio vaccine (*V. alginolyticus*) and the adjuvant ALGEL with vibrio antigen adsorption has been standardized. This vaccine has been tested experimentally in the sea bass. After the 6th week in challenge studies, significant results were obtained in the vaccinated seabass fingerlings as compared to the control. Single dose of immunization gave protection with 80% relative percentage of survival. After booster a dose, the relative percentage of survival improved to 90%

A pilot study *on vitro* and *in-vivo* analysis of fucoidan as a biodegradable adjuvant carried out. Polyclonal antibodies were raised against *Perkinsus* antigens for the development of a lateral flow assay for detecting *Perkinsus* infections.

Under the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD), surveillance of wild bivalves along the east and west coasts of India resulted in collection of 988 samples belonging to 12 species of bivalves and their screening for OIE listed pathogens. The invasive mussel species, *Mytella strigata* reported recently from Kerala was also screened for *Perkinsus* infection and was positive. *P. olseni* was observed in *Perna viridis, Perna indica, Pinna bicolor, Saccostrea cucullata, Paphia malabarica, Geloina bengalensis* and *Mytella strigata. P. beihaiensis* was observed in *Perna., P. malabarica, G. bengalensis, Modiolus modiolus, Saccostrea cucullata and M. strigata.* Mixed infections were observed in *P. malabarica, P. viridis, G. bengalensis, M. modiolus and M. strigta*.

In the research project monitoring Antimicrobial Resistance (AMR) in fisheries and aquaculture, *E. coli*, *Vibrios*, *Staphylococcus* isolated from marine fishes cultured in cages in Kerala and Karnataka. *E. coli* had very high resistance against cefpodoxime, cefotoxime, amikacin and imipenem. *Vibrios* had very high resistance against cefotoxime. *Staphylococcus* had very high resistance was seen against penicillin G.

In the All India Network Project on fish health, a pilot study *on vitro* and *in-vivo* analysis of fucoidan as a biodegradable adjuvant was carried out. Economic loss was assessed in mussel farms at Kasaragod and seasonal impacts on biochemical and immunological parameters associated with haemolymph and mantle fluid of *Perna viridis* was also carried out. Acute ionic-modulatory responses in Mangrove red snapper, *Lutjanus argentimaculatus* on altered salinity exposures were studied. Tissue specific indigenous bacterial densities in Asian green lipped mussel (*Perna viridis*) studied which confirmed the non-sterile nature of tissues including hemolymph in apparently healthy conditions.

Continuing the legacy of developing nutraceuticals form seaweeds CMFRI's 6th CadalminTM Antihypertensive extract (CadalminTM AHe) from seaweeds was released by the Director General, Indian Council of Agricultural Research, Dr. Trilochan Mohapatra on 28th May 2019. Further work on marine bioprospecting involved research on macrocyclic lactones from seaweed-associated heterotroph as prospective anti-infective agents. Three homologues members of the 24-membered macrocyclic lactone family, named as bacvalactones 1-3 bearing 13-*O*-ethyl (1), 15-*O*-furanyl-13-*O*-isobutyl-7-*O*-propyl propanoate (2), and 15-*O*-furanyl-13-*O*-isobutyl-7-*O*-propyl propanoate-7, 24-dimethyl (3) functionalities were acquired through bioactivity-guided purification. Three drimane sesquiterpene quinols were purified from *Gracilaria Salicornia.* Anti-inflammatory cembrane and stomopnolides was isolated from sea urchin *Stomopneustes variolaris*. Oxygenated elansolid type macrolides were isolated from marine heterotrophic *Bacillus* as antimicrobial agents against multidrug resistant pathogens. A heterotrophic *gamma proteobacterium* isolated from seaweed *Hypnea valentiae* . From the buccinid gastropod mollusc *Babylonia spirata* a glycosaminoglycan-xylopyranan attenuating pro-inflammatory 5-lipoxygenase was isolated. Macrocyclic lactones extracted from *Amphioctopus neglectus* was found to reduce angiotensin-II induced cardiac hypertrophy (thickening of heart muscle).

Mean survival rate of cobia fingerlings produced at Mandapam was 9 % and pompano was 23.5%. Orange spotted grouper survival at Visakhapatnam was 12%. At Karwar broodstock development of *Acanthopagrus berda, A. latus, Lutjanus argentimaculatus,L johnii and Siganus vermiculatus* is carried out. At Calicut Centre,broodstock development and induced breeding trials in *Acanthopagrus berda* is being carried out in 5 ton capacity tanks fitted with recirculatory aquaculture system (RAS). At Madras centre, the broodstock of Indian Halibut *Psettodes erumei*is being maintained in the hatchery and studies on their behaviour and adaptation. Genetic management of breeding populations of the cobia and the silver pompano is done at Mandapam. The genetic variability in the broodstock populations of cobia and silver pompano is being monitored for producing high quality seed to farmers and other stakeholders. In crustaceans, sand lobster seed production trials continue at Madras Centre and sea ranching of *Penaues semisulcatus* is done at Mandapam. Through the sale for fish seed of both food fish and ornamental fish, Mandapam Centre generated a revenue of ₹14.6 Lakhs. Calanoid copepods *Acartia southwelli*, *Parvocalanus crassirostris, Bestiolina similis, Pseudodiaptomus serricaudatus* and *Temora turbinata,* cyclopoid copepods *Oithona brevicornis, Dioithona oculata* and harpacticoid copepod *Euterpina acutifrons*are being maintained regularly at Vizhinjam. Vizag Centre, mass produced *Parvocalanus* and standardized the protocol for production of *Nanochloropsis* algal concentrate. As a health management measure, in the cobia broodstock, mass immunization using a multivalent vaccine resulted in better immunity. Harmful algal blooms (HAB) resulted in mortality several brood fishes of cobia at Mandapam. *Noctiluca scintillans* was identified as the harmful alga. *Trichodiniasis* is the most rampant ectoparasite found in the cobia hatchery which was managed using both chemicals and immunostimulants. The micro-nursery established at Vizhinjam for green mussel seeds moved forward with the sale of seeded ropes. The NFDB funded marine fish brood bank became fully functional at our Vizhinjam Centre.

In the area of maricuture, experiments on use of antifouling agents in cages indicated that commercially available antifouling coating, TORPEDO, a vinyl antifouling paint with cuprous oxide and organic biocides as active ingredients for long term resistance to weed, shell and animal fouling reduces biofouling significantly. Farming of lobsters in cages from an initial weight of ~85 g to ~338 g fetched a farm gate price of ₹2000 per kg. In an Integrated Multi-Trophic Aquaculture (IMTA) with cobia and seaweeds the yield was 1.105 t of fish and 19.2 t of seaweed. Studies on different feeding frequencies such as 3, 4 and 6 times in a day in orange spotted grouper fingerlings showed that fingerlings fed 4 times in a day showed better performance at stocking density 300 and 400/m3. When Indian pompano fingerlings were reared in a RAS nursery, growth from 0.5 g to 8 g could be achieved in two months. Orange spotted groupers attained 1.5 kg body weight in 330 days of culture in ponds. After standardization of multivalent vibriosis vaccine *in-vitro* and experimental studies, the field application trials carried out in the cage farmed cobia showed that regular epizootics observed in cage cultured cobia every year during the months of July to September (pre-monsoon season) was successfully prevented by immunization. Intersex gonads were observed for the first time in cobia from Mandapam which is predominantly gonochoristic. Pompano brood-bank established at Vizhinjam RC of CMFRI started functioning this year after the construction of three buildings; Laboratory cum algal-culture unit, RAS building and hatchery buildings. As an alternative to mussel farming, the farmers have been encouraged to take up oyster farming and training in edible oyster farming was imparted to the farmers in Punjakkad in Kannur District and Ori in Kasaragod District.

Under the All India Network Project (AINP) in mariculture, brood stock development of banded grunter (*Pomadasys furcatus*) is attempted at Vizhinjam. Eggs of pink ear emperor fish (*Lethrinus lentjan*) obtained from volitional spawning round the year in the Vizhinjam hatchery is sea ranched regularly. Marcia's anthias, *Pseudanthias marcia* a very attractive and highly priced ornamental fish spawned volitionally at Vizhinjam under captive conditions. Variations in growth were observed when silver pompano was farmed in different ecosystems. Cage farming trials of rabbit fish, carangids, orange spotted grouper, red snapper, pompano, Asian seabass and pompano formed the major body of the work in this project. Viability of intercropping silver pompano in shrimp ponds was tried and found viable. GIS based spatial model for identifying potential mariculture sites along Gujarat coast was also completed. Several training programmes and mariculture activities were conducted under the scheduled caste sub-plan project also.

In the project on developing conservation plans for biologically sensitive areas along the Indian coast, Dharmatar, Dabhol, Kalbadevi and Bangkot creeks in Maharashtra were monitored for their biodiversity. Mulki, Primareia and Kaup rock ecosystems in Karnataka, Kadalundi, Korappuzha, Thikkodi, Kolavipalam and Dharmadom estuaries in Kerala, Punnakayal and Palayakayal estuaries the confluence of the perennial river Thamirabarani, Manakudy estuary, a confluence of the river Pazhayar, Udhayamarthandapuram bird sanctuary, Point Calimere Wildlife and Bird Sanctuary situated on a low promontory on the Coromandel Coast in Nagapattinam District in Tamil Nadu and Bhairavapalem characterised by estuary, open sea, mangroves, backwaters and creeks, Pudimadka a fishing village in Visakhapatnam district in Andhra Pradesh were also the sites for biodiversity was monitored.

In the project on the investigations on the Scyphozoan and Cubozoan jellyfish diversity and distribution along the Indian Coast, apart documenting jelly-fish biodiversity, redescription of the enigmatic jellyfish, *Crambionella annandalei* (Cnidaria: Scyphozoa) from Indian waters was done. In the assessment of resilience potential of coral reefs of India, surveys were made at Havelock and Neil Islands of Andamans. Underwater survey was conducted in the reef flats and fore reefs of Kavaratti atoll indicated widespread outgrowth of anemone over the hard corals in the northern Agatti region. Disease incidences were prevalent in the Amini atoll with Pinkline syndrome having the major incidence.

In molecular taxonomy and phylogeny of Cones (cone snails) andStrombs (Mollusca, Gastropoda) of the Indian coast, 20 species (57 individuals) from the families Conidae and Strombidae were collected from nine sampling sites along both the coasts of India including Andaman and Nicobar Islands. Integrated taxonomy reveals the exceptional phenotypic plasticity in *Conus (Pinoconus) catus* among the Andaman and Lakshadweep archipelagos.

The Kadalundi-Vallikunnu Community Reserve (KVCR) is the first Community Reserve of Kerala, declared in October 2007, and lies partly in Kozhikode and Malappuram districts of the State. The Community Reserve which has a total area of 153.84 ha is characterised by the presence of mangroves, mud flats and rich biodiversity. The project was envisaged to document the biodiversity of KVCR and to delineate the value of various ecosystem services rendered by this wetland. Based on the studies conducted several management measures have emerged and it was suggested to Kerala State Biodiversity Board (KSBB) to remove sand form the bar mouth, planting of mangroves, creation of mangrove nurseries, capacity building to local people and creation of an interpretation centre. Taxonomical Investigation of lesser known marine animals of India- Phylum Cnidaria (Class: Anthozoa) and Phylum: Porifera (Marine) were also conducted.

In the research project on micro-level environmental management plans for selected critical habitats for ecosystem health and sustainable production, Ecosystem Health Index (EHI) developed was used to monitor the selected coastal ecosystem during the post-monsoon, pre-monsoon and monsoon seasons. Sensitive habitats like mangroves and seagrass beds were assessed for ecosystem health in Gujarat for the development of sustainable micro-level environment management plans (EMP). Participatory protocol for mangrove nursery management has been developed at Mandapam.

In the project on impact of climate extremes and disasters on ecosystem functioning with special emphasis on fisheries and mariculture, ecological system based changes were low due to tropical cyclone and the socio-economic impact was high and there is a need to develop early warning and vessel tracking systems to increase the preparedness of fishers to unexpected extreme events. For abatement of coastal pollution through bioremediation, experiments indicated that restoration of more habitats for seagrass and seaweed along the coastline and large scale mariculture of seaweeds is the immediate need to mitigate the adverse effects of ocean acidification more effectively. Impact of heavy metals and ammonia toxicity on mangroves and other aquatic plants were studied and was established how the heavy metals thrown with industrial effluent in Kochi backwaters can damage these important biofence. Cadmium found in the cephalopod processing plant waste water was bioremediated using *Eichhornia crassipes* plants.

In the assessment of coastal and

marine pollution in selected maritime States of India, estimated seasonal variation in micro and meso plastics contamination levels in the sediment of selected mangrove ecosystems in Ernakulam district, showed higher levels of microplastics. Spatial and temporal variations in the marine plastic litter (MPL) and its relative percentage in the quantity of fish caught from the trawling grounds off Cochin, Ratnagiri, Mumbai and Veraval along the west coast as well as Visakhapatnam from the east coast of India was estimated.

In the project on marine macrophytes in India – Resources, dynamics and ecosystem services, one of the major threats faced by the seagrass *Halophila beccarii* bed observed in Kadalundi estuary is the sand bar formation near to the bar mouth and its further extension to the seagrass bed and the habitat degradation. Production of red seaweed *Kappaphycus alavarezii* through mariculture along south east coast of India was estimated as 350 to 1250 tonnes in dry weight. Seagrass transplantation experimental studies were conducted at Panaikulam and Maunaikadu coasts. Blue carbon stock of sea grass meadows of Palk Bay was quantified to 0.00177 TgCe/year (teragrams of carbon dioxide equivalent) and that of Gulf of Mannar was estimated to 0.04395 TgCe/year. A mangrove nursery (*Ceriops tagal*, *Rhizophora mucronata, Avicenia marina* and *Pamphis acidula)* has been developed in Thoppukadu mangrove area near Devipatinam with involvement of local fishers.

In the area of climate change, ontogenetic and seasonal variations of smooth blaasop, *Lagocephalus inermis* was studied. Seasonal analysis of diet using cluster analysis showed that maximum similarity was between pre-monsoon and post-monsoon to which monsoon got linked. SIMPER analysis showed that major prey items contributing to the dissimilarity between pre-monsoon, post-monsoon and monsoon was *Saurida* spp. and crabs, while shrimp and *Apogon* spp. contributed to the dissimilarity between monsoon and post-monsoon. Body size-dependent response and feeding habits of sardine and mackerel along southwest coast of India when studied with multiple correlation analysis and linear regression models indicates significant change in mean length of Indian mackerel (*Rastrelliger kanagurta*) and Indian oil sardine (*Sardinella longiceps*) corresponding to SST (1960-2016) and SSC (1998-2016), with the effect being highest for the pre-monsoon (February-May) sea surface temperature (SST) and post-monsoon (October to January) sea surface cooling (SSC). In climate change modelling, the influence of oceanographic drivers on small pelagic fishery, it was found that, major small pelagic fishery along the southwest coast rely on the seasonally occurring upwelling and downwelling phenomena as well as the coupled ocean-atmosphere dynamics. Analysing spatio-temporal variations of chlorophyll concentration along Indian coastal zones, cumulative trend of two decades reveals that the southeast zone exhibited increasing chlorophyll trend in monsoon season, while other zones exhibited decreasing trend in all seasons. Under fishery and gear vulnerability to climate change, predicted changes in the vulnerability of the fishery and harvest methods under various representative concentration pathway (RCP) scenarios reveals that both the gear vulnerability and fishery vulnerability across the regions increase under the current harvesting strategies. A wetland mobile application and associated website with access to scientific communities as per the project requirement has been developed and transferred along with the operational manual by Space Applications Centre (SAC) – ISRO. Under Climate Smart Village (CSV) development, vulnerability assessment 21 coastal villages were assessed. Climate Clubs as a socio-economic and ecological resilient strategy lead to a first of its kind network of climate clubs for enhancing coastal resilience.

In the economic sustainability and trade section, marine fish landings were valued at the fish landing centre level and retail level. State-wise valuation across value chains was also performed for Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Odisha, Puducherry, Tamil Nadu, West Bengal and Daman and Diu. Species wise valuation was also done. Macroeconomic indicators at the national level were, total operating cost ₹ 34,702.24 crores and the net operating income ₹261,78.89 crores. The average capital productivity worked out to 0.57 and the gross value added to the marine fisheries sector was estimated at ₹40,790.36 crores, which is 67 per cent of the gross revenue. Economic performance of fishing methods indicated that, over all the capital productivity was very much efficient in case of non-mechanized bottom set gillnet (0.42). This is due to the less proportion of crew wages as most of the non-mechanized units are operated by family labour only. An economic analysis of fishing and value chains of the deep-sea fishing industry based at Thoothoor, Tamil Nadu was also carried out based on primary surveys. State-wise price behaviour of landing centre prices of major species was also studied for the year 2019. Marine fish market efficiency across states and marine fish consumption paradigms and spatial demand across India was also worked out. E-marketing Intervention in Indian fisheries sector and development of an integrated Fish Market and Price

Information System (FMPIS) for Indian fisheries sector sampling 1000 fish markets is progressing. A web portal showcasing four domains namely, fish, market, price information system and e-auctions was done in association with NFDB. A field manual with 150 fish species in which 120 marine species and 30 inland species mostly traded in the different fish markets in India was developed to include in the software developed for the tablets with their common names, scientific names, and vernacular names across different coastal states for the data collection of the FMPIS project. Under the responsible marine fisheries governance: compliance analysis and peripatetic capacity development project, a study was carried out to know about the general perception about Kerala marine fisheries regulations, compliance status and the cognitive deficiencies which need capacity development (CD) interventions among the fisher folk. Peripatetic capacity development interfaces were conducted at different locations in association with the Department of Fisheries, Government of Kerala. Complete stoppage of illegal fishing activities is very essential to protect the declining fish wealth. Similarly, the strict implementation of the regulations and rules with assured compliance (46.8%) and increasing the duration of fishing ban period (12. 8%) were other two important strategies suggested by the ring seine fishermen to protect the fish stock resources in a sustainable way.

In the research project on diversified livelihood options and gender mainstreaming for entrepreneurship development in marine fisheries sector of India, extensive field surveys were undertaken in Ramanathapuram District of Tamil Nadu, for the documentation of fisheries related/non-fisheries related diversified livelihoods (DLOs). Highest mean annual income of small-scale shell processing units was to the extent of ₹ 7,86,600. This is widely practiced in Rameswaram, Pamban, Thondi and Keezhakarai areas of the District, with 342 man-days of work. This was followed by boat building by fishers of Vedalai, Rameswaram, Kezhakarai and Soliyakudi. The owners of boat building units consisting of both mechanized and motorized units earn on an average mean annual income of ₹ 5,42,400 with 319 man-days of work. Under the non-fisheries sector, the highest mean annual income was obtained by fishers practicing mat making using palmyrah leaf with an income of ₹ 66,000 with 180 man-days of employment. Mat making using palmyrah leaves is practiced in Thamaraikullam and Muthupettai areas of the District. It was observed that all the fisheries related/ non-fisheries related enterprises are standalone enterprises. In *Theeramythri* programme envisaged to provide alternative livelihood options for the fisherwomen, a Public, Panchayat, Professional Partnership (PPPP) model, a road map was developed for the improved effectiveness and effective implementation for ensuring and economically viable units. After *Theeranaipunya* training program 83.5 per cent of the trainees searched for jobs got jobs in different organisations which included private firms and government agencies. When comparing the different districts where the *Theernaipunya* trainees are currently placed it was found that Ernakulam District provided placements for 67.30 % of trainees followed by Kozhikode (50.00%). Fishers' welfare impact assessment on the satellite-based ocean information services: An appraisal, is another project where data analysis on 2586 samples respondents (1474 users and 1112 non-users of the satellite information forecast by INCOIS was completed and the results are presented. ATIC entertained 5608 students and 1377 entrepreneurs as visitors and generated a revenue of ₹ 7,05,985 through sale of CMFRI products and services.

कार्यकारी सारांश

सी एम एफ आर आइ में वर्ष 2019 के दौरान 37 गृहांदर परियोजनाएं,39 बाहरी वित्त पोषित परियोजनाएं और 13 परामर्श परियोजनाएं संचालित की गयीं।

भारत में वर्ष 2019 के दौरान 3.56 मिलियन टन समुद्री मछली अवतरण अनुमानित किया गया। यह वर्ष 2018 के आकलन से 2.1% अधिक था। दो वर्षों के पश्चात् समुद्री मछली पकड़ में गुजरात को पीछा कराते हुए तमिल नाडु आगे आया। गुजरात, महाराष्ट्र, गोवा, केरल और पुदुच्चेरी में समुद्री मछली पकड़ में कमी और दमन और दीव, कर्नाटक, तमिल नाडु, आंध्रा प्रदेश, ओड़ीषा और बंगाल में वृद्धि महसूस हुई। ChloRIFFS परियोजना में गुजरात तट पर समुद्री मछली अवतरण का मानचित्रण किया गया।

भारत के तटीय समुद्रों में प्राथमिक उत्पादन के लिए प्रतिमान की परियोजना के अंतर्गत यह देखा गया कि उत्स्रवण के अतिरिक्त, गर्मी के दौरान मानसून की उच्च वर्षा ने भी दक्षिण पूर्व अरब सागर (एस ई ए एस) की तटीय उत्पादकता में महत्वपूर्ण योगदान दिया। अध्ययन ने विशेष रूप से नदी के निर्वहन के लिए पर्याप्त इन-सीटू डेटा की मदद से उन विशिष्ट वर्षों के विस्तृत विश्लेषण के लिए गुंजाइश प्रस्तावित की।

समुद्री मछली अवतरण, जीव विज्ञान, नीति सलाह और हितधारक परामर्श के आंकड़ों में राज्यवार बारीकियों को अलग-अलग वर्गों के रूप में प्रस्तुत किया गया है, जैसे कि गुजरात, महाराष्ट्र, कर्नाटक और गोवा, केरल और लक्षद्वीप, तमिलनाडु और पुदुच्चेरी, आंध्रा प्रदेश, बड़े वेलापवर्ती संसाधन, द्विकपाटी संसाधन, जठरपाद संसाधन, उपास्थिमीन, ओडीषा और बंगाल और स्टेक धारक परामर्श। इन खंडों को मात्स्यिकी संपदाओं का टिकाऊ प्रबंधन नामक सामान्य शीर्षक के अंतर्गत पहुँचाया जाता है।

मछली आनुवंशिकी और जीनोमिक्स के क्षेत्र में, भारतीय स्कड *डेकाप्टीरस रसेली* के पूरे माइटोजीनोम, को चित्रित किया गया है। माइटोकोन्ड्रियल कन्ट्रोल रीजियन मार्केर्स के उपयोग से महासागरीय वाइट टिप शार्क (*कारकारिनस लोंजिमानस*) और स्कालप्ड हैमरहेड शार्क *स्फिरना लेवीनी* की आनुवंशिक जीवसंख्या संरचना चित्रित की गयी और, जैसा कि भारतीय तट के भीतर आनुवंशिक विभेदीकरण की कमी और महासागरीय घाटियों के बीच महत्वपूर्ण भेदभाव पता चला। हिंद महासागर स्क्विड *यूरोटूथिस डुवासेली* पर की गयी आनुवंशिक जांच से गुप्त विविधता की उपस्थिति का संकेत प्राप्त हुआ, क्योंकि भारतीय तट पर 3 अलग-अलग समूहों का पता चला था। पूर्ण माइटोजीनोम और भागिक माइटोकोन्ड्रियल डी एन ए विश्लेषण (सी ओ आइ और कंट्रोल) का उपयोग करते हुए पंक शूली महाचिंगट *पानुलिरस पोलीफैगस* में दो गुप्त उप-प्रजातियों को प्रलेखित किया गया। *पी. मलबारिका* में ट्रांसक्रिप्टोमिक जांचों से, अष्टमुडी और धर्मडम नदीमुखों से एकत्र किए गए सीपियों में अपरेगुलेटड और डाउनरेगुलेटड किए गए जीनों के बारे में जानकारी प्राप्त हुई, जो जीन की अभिव्यक्ति पर पर्यावरण के प्रभाव के बारे में संकेत देता है। विभिन्न संभरण सघनता, खिलाने की आवृत्ति और वृद्धि होर्मोन एवं इन्सुलिन जैसे बढ़ती कारक जीन अभिव्यक्ति को संतरा चित्तियों वाले ग्रूपर के बढ़ती निष्पादन के साथ सहसंबद्धित किया गया।

कोशिका और ऊतक संवर्धन में, *पी. मार्गरिटिफेरा* के मैन्टिल उपकला कोशिकाओं को जीवनक्षम स्तर पर पांच वर्ष से अधिक अनुरक्षित किया जा रहा है, जो अकशेरुकी कोशिका संवर्धन अनुसंधान में पहली बार किया जा रहा है। इन-विट्रो संवर्धित मैन्टिल उपकला कोशिकाओं का दीर्घकालिक भंडारण (60 दिन) ग्लिसरॉल, डी एम एस ओ की 10% सांद्रता को क्रायोप्रोटेक्टेंट के रूप में उपयोग करके हासिल किया गया। अनफ्रोज़ेन नियंत्रण (हिम संरक्षण के बिना) में क्रायोप्रोटेक्शन के बाद इष्टतम सेल व्यवहार्यता

ग्लिसरॉल के साथ 98% और डीएमएसओ के साथ 94% थी। हिमपरिरक्षित कोशिकाओं के उपयोग से न्यूक्लियार बीड पर नेकर लगाए जाने पर, 60 दिनों के निषेचन के बाद बेहतरीन ब्रिक और मोर्टार पैटेर्न व्यक्त हुआ। नेकर बायोमिनरीलाइजेशन (लस्ट्रिन, एमोर्फस कैल्शियम कार्बोनेट बाइंडिंग प्रोटीन, कार्बोनिक एनहाइड्रेज 1 और मोलस्क कवच संरचना प्रोटीन) में शामिल जीनों को प्रवर्धित किया गया है और अनुक्रमण के लिए भेजा गया। ताजे मैन्टिल टिशू और संवर्धित उपकला कोशिकाओं से उपकला कोशिकाओं के डी एन ए सामग्री की तुलना करने के लिए फ्लो साइटोमेट्री द्वारा इन-विट्रो संवर्धित मैन्टिल उपकला कोशिकाओं की केन्द्रक डी एन ए सामग्री का विश्लेषण करने के लिए परीक्षण किए गए। *पी. फ्यूकेटा* की मैन्टिल ऊतक निचोड से प्रमुख जैव सक्रिय यौगिकों की जांच प्रगति पर है। मोतियों को समुद्री स्रोतों से लिए गए कैरागीनन, कोलाजन और काइटोसन जैसे बायोपोलिमरों से आवृत किया गया। इन बायोपोलिमर से आवृत मोतियों का एस ई एम विश्लेषण किया गया। कोलाजन और काइटोसन के संयोजन से आवृत मोतियों में बेहतर आवरण देखा गया। जैव सामग्रियों के विभिन्न संयोजनों के स्काफोल्ड, मैन्टिल कोशिकाओं में उनके संबंध का परीक्षण करने के लिए तैयार किए गए।

eDNA अनुक्रमण के माध्यम से पहचानी गयी नई प्रजातियों को पारंपरिक वर्गीकरण द्वारा सत्यापित किए जाने की आवश्यकता है। स्थानिक विश्लेषण के माध्यम से, इंटरेक्टिव जी आइ एस बथिमेट्री और स्थानीय भूवैज्ञानिक और भौगोलिक विचारों के आधार पर स्थानों की पहचान और टैगिंग की जाती है। प्रतिमान स्थानों को लाइव मैप में बदलने का प्रयास किया गया है ताकि इसे गूगिल एर्थ पर ओवरलैड किया जा सके और स्मार्ट फोन पर उपलब्ध कराया जा सके।

मछली पोषण और खाद्य जैव प्रौद्योगिकी में, एक नयाचार विकसित किया गया, कच्चे माल की 24-31% उपज के साथ कपास बीज प्रोटीन का उत्पादन। कपास बीज खाद्य में 42% प्रोटीन की तुलना में इस में 69-71% प्रोटीन मौजूद है।पोम्पानो (*ट्रेकिनोटस ब्लोची*) खाद्य में मूल्यांकन किए जाने पर पता चला कि, पचास प्रतिशत मछली खाद्य को कपास बीज खाद्य प्रोटीन सांद्रता के साथ बदल दिया जा सकता है। मछली अपशिष्ट का उपयोग करते हुए काले सैनिक मक्खी (बी एस एफ) के साथ कीट प्रोटीन का उत्पादन सबसे अधिक बायोमास और प्रोटीन सामग्री के रूप में हुआ। डिंभक की लिपिड सामग्री (%DM आधार) 36-38% से भिन्न होती है, और बी एस एफ डिंभक खाद्य से वसा निकालने के लिए एक तरीके का अनुकूलन किया गया। बी एस एफ के डिंभक में लिपिड का एक स्तर (~ डीएम के आधार पर 35%) होता है, जो कि दुर्गंध की समस्या का कारण बनता है और इससे खाद्य निर्माण और भंडारण में समस्याएँ होती हैं। अनुकूलित प्रक्रिया, जो वसा निकाले गए बी एस एफ एल के उत्पादन में सहायक थी,डी एम आधार पर 10% से कम थी।

सिल्वर पोम्पैनो (*टी. ब्लोची*) की आहार संबंधी लाइसिन की आवश्यकता सूखे आहार के 2.40 से 2.45% (5.71 से 5.83% आहार क्रूड प्रोटीन) के रूप में अनुमानित की गई। मेथिओनिन की आवश्यकता शुष्क आहार के 1.16 से 1.18% (2.76 से 2.83% आहार क्रूड प्रोटीन) में पाई गई। इंसुलिन जैसे वृद्धि कारक (आइ जी एफ) जिगर और मांसपेशियों में जीन अभिव्यक्ति उपरोक्त निष्कर्षों का समर्थन करते हैं। सेनेडेसमासिए कुटुम्ब के हरा शैवाल *कीलास्ट्रेल्ला वाकोलेटा* का बड़े पैमाने पर संवर्धन का मानकीकरण किया गया और पोषक तत्व प्रारूप का विवरण दिया गया। पेर्कुला क्लाउन मछली *एम्फीप्रियोन पेर्कुला* के खाद्य के प्रतिस्थापक के रूप में *सी. वाकोलेटा* खाद्य के प्रभाव पर भी अध्ययन किया गया। परिणामों से पता चला है कि कीलास्ट्रेल्ला खाद्य को एक बहुत अच्छे प्राकृतिक रंग बढ़ाने वाले एजेंट के रूप में उपयोग किया जा सकता है। मछली खाद्य के बदले में कीलास्ट्रेल्ला खाद्य को 10% की दर से शामिल किया जा सकता है ताकि वृद्धि को प्रभावित किए बिना मछली के रंग को बढ़ाया जा सके।

गहरा सागर महाचिंगट *प्यूरुलस सीवेली* के फैटी एसिड प्रोफाइल ने संकेत दिया कि उच्च ऊर्जा वसा अम्ल ई पी ए (10.02% और डी एच ए 11.2%) प्रमुख फैटी एसिड थे। उच्च हाइपोकोलेस्टेरोलेमिक / हाइपरकोलेस्टेरोलेमिक अनुपात (> 2.4) और निचला एथेरोजेनिक (<1.8) और थ्रोम्बोजेनेसिटी (<0.3) सूचकांक महाचिंगट को एक आदर्श स्वास्थ्य भोजन बनाते हैं। संभावित पोषक स्रोतों के रूप में आम तौर पर उपलब्ध उष्णकटिबंधीय क्लोरोफाइटन समुद्री शैवाल की खोज करते हुए, छह उष्णकटिबंधीय हरे समुद्री शैवालों को संभावित स्वास्थ्य भोजन के रूप में इस्तेमाल किया जा सकता है। *उलवा लैक्टुका* (~ 2.14) के n-3 / n-6 अनुपात से पता चला कि समुद्री शैवाल की इस प्रजाति की खपत स्वास्थ्य संवर्धन के लिए आदर्श होगी। कीटोमोर्फा लिनम कैल्सियम, मग्नीशियम और फोसफरस से समृद्ध पाया गया। महाचिंगट पोषण में, चिंराट सिर अपशिष्ट आधारित खाद्य (सी आइ एफ टी से) और सी एम एफ आर आइ खाद्य के मूल्यांकन के परिणामस्वरूप शूली महाचिंगट में कम वृद्धि देखी गयी। उनके खाद्य के प्रति प्रतिक्रिया समय के लिए गीले खाद्य का परीक्षण किया गया। मछली मांस (थ्रिस्सा) देने पर खपत के लिए अधिक समय के साथ तेज़ी से प्रतिक्रिया देखी जा सकी। मछली के मांस की तुलना में सीपी और स्क्विड की तेज़ी से खपत की गयी। महाचिंगटों के लिए केकड़े का मांस कम से कम आकर्षक था।

मछली स्वास्थ्य प्रबंधन अनुसंधान परियोजना में, ग्यारह वंश (*मिक्सोबोलस, सेराटोमिक्सा, मिक्सोडेवसिया, स्यूडालटोस्पोरा, स्फीरोस्पोरा, स्पेरेरोमिक्सा, एल्लिप्सोमिक्सा, ऑरबाचिया, हेन्नेगुया, ओर्थोलिनिया और श्ज़ोक*) से संबंधित मिक्सोस्पोरियन्स पाए गए। प्रसार 52.61% की औसत व्यापकता के साथ 14.6% से 100% तक भिन्न है। *प्लानिलिज़ा माक्रोलेपिस* से मिक्सोस्पोरीन की एक नयी प्रजाति, *मिक्सोबोलस चाइनेन्सिस* एन. एसपी. का वर्णन किया गया। समुद्री अलंकारी मछली *एकान्थूरस ज़ांतोप्टीरस* से मिक्सोस्पोरीन की एक नयी

प्रजाति, *सेराटोमिक्सा ज़ान्थोप्टीरी* एन. एसपी. का वर्णन किया गया। फ्लूरसेन्ट स्वस्थाने संकरण का उपयोग करते हुए ऑरबाचिया-विशिष्ट जांच के साथ *कैरांक्स इग्नोबिलिस* को संक्रमित करने वाले *ए. इग्नोबिली* एन. एसपी. के विकास के विभिन्न चरणों पर विस्तृत अध्ययन किया गया। ऊतक विज्ञान यह संकेत देता है कि *ए. इग्नोबिली* एन. एसपी. यकृत पित्त नलिकाओं के भीतर विकसित होता है और परिपक्व मिक्सोस्पोर पित्ताशय की थैली में ले जाता है और संग्रहीत किया जाता है। वर्तमान अध्ययन ऑरबाचिया वंश के ज़ीलोज़ोइक स्वभाव को स्पष्ट करता है। *कैरांक्स इग्नोबिलिस* के पेरिटोनियल कैविटी से डिडिमाज़ोइड ट्रेमटोड की नयी प्रजाति, *नेमाटोबोथ्रियम इग्नोबिली* एन.एसपी. को पाया गया। असामान्य रूप से लंबे इस ट्रेमटोड का आकार 400 x 0.421 मि. मी. था। *मुगिल सेफालस* को संक्रमित करने वाली एकान्थोसेफालन परजीवि की नयी प्रजाति *नियोकाइनोरिन्किस सेफाली* एन.एसपी. की पहचान की गयी और इसका वर्णन भी किया गया। कारवार में पिंजरा पालन की गयी, नर्सरी में पालान की गयी और वन्य मछलियों में परजीवियों की उपस्थिति का आकलन करने के लिए अध्ययन किया गया। *लैटस कैलकारिफर* में समुद्री लीचों, हेमिन्थ कृमियों और आइसोपोड़ों (*सिमोथोआ प्रजाति*) का संक्रमण देखा गया। *टी. ब्लोची* से *अर्गुलस क्वाड्रिस्ट्रियाटस*, *ए. ओसेल्लाटम* और *डेप्लिक्टानम* प्रजातियों (मोनोगीनन) को देखा गया और जलजीवशाला मछलियों के त्वचा और क्लोम में *ऊडिनियम* प्रजातियों के साथ *राचिसेन्ट्रोन कनाडम* संक्रमण और *आर. कानागुर्टा* और *सी. इग्नोबिलिस* में सिमोथा से संक्रमण की रिपोर्ट की गयी। *एकान्थोपाग्रस बेर्डा* में *एकाइनोसेफालस ओवरस्ट्रीटी* और *कालिगस* प्रजाति के डिंभकों का संक्रमण देखा गया।

समुद्री केकड़ों में हीमोलिम्फ़ रोगाणुओं में गैर-राइबोसोमल पेप्टाइड सिंथेटेज़ (एन आर पी एस) जीन का आनुवंशिक विश्लेषण किया गया। पांच विभिन्न प्रजातियों के जीवाणु प्रभेदों से एन आर पी एस जीनों की पहचान की गयी। समुद्री केकड़े हीमोलिम्फ़ माइक्रोबयोटा नवीन एन आर पी एस जीन और प्राकृतिक उत्पादों की खोज करने के लिए एक अब तक अन्वेषण नहीं किया गया तरीका है। एंटीऑक्सीडेंट प्रणालियों की पर्यावरणीय प्रतिक्रिया को समझने के लिए एशियन हरा अधर वाले शंबु (*पेर्ना विरिडिस*) के हेमोलिम्फ में एंटीऑक्सीडेंट प्रोफाइलों का अध्ययन किया गया। परिणामों से पता चला कि सभी अध्ययन किए गए घटकों के प्रोफाइल अर्थात् GSH, GPx और SOD को प्रमुख हद तक प्रभावित किया गया था।

ऑक्सीडेटिव स्ट्रेस के जैव रासायनिक मार्कर के रूप में मालोनडिएल्डिहाइड (एम डी ए) की मात्रा निर्धारित करते हुए, केरल तट की तीन वाणिज्यिक प्रमुख द्विकपाटी प्रजातियों के गलफड़े और पाचन डाइवर्टिकुला में लिपिड पेरोक्सीडेशन को मापा गया केरल तट की तीन वाणिज्यिक प्रमुख द्विकपाटियों *वी. पैराहीमोलिटिकस* और *ई. कोली* की व्यापकता देखी गयी।

निदान और टीके पर सी आर पी के अंतर्गत, एक मोनोवालेंट विब्रियो टीका (*वी. एल्गिनोलिटिकस*) और विब्रियो एंटीजन अवशोषण के साथ सहायक ALGEL को मानकीकृत किया गया। समुद्री बास में इस टीके का प्रयोगात्मक रूप से परीक्षण किया गया। चुनौती के अध्ययन में 6 वें सप्ताह के बाद, नियंत्रण की तुलना में टीका लगाए गए समुद्री बास अंगुलिमीनों में महत्वपूर्ण परिणाम देखे गए। प्रतिरक्षण की एकल खुराक ने जीवित रहने के 80% सापेक्ष प्रतिशत के साथ सुरक्षा दी। बूस्टर खुराक के बाद, जीवित रहने के सापेक्ष प्रतिशत में 90% तक प्रगति हुई। फुकोडियन के इन विट्रो और इन-विवो विश्लेषण पर बायोडिग्रेडेबल एडजुवेंट के रूप में एक प्रारंभिक अध्ययन किया गया। पेरकिनसस संक्रमण का पता लगाने के लिए पार्श्व प्रवाह परख के विकास के लिए पेरकिनसस एन्टीजनों के खिलाफ पॉलीक्लोनल एंटीबॉडी लिए गए।

जलीय पशु रोगों (एन एस पी ए ए डी) के लिए राष्ट्रीय निगरानी कार्यक्रम के अंतर्गत, भारत के पूर्व और पश्चिम तटों के प्राकृतिक द्विकपाटियों की निगरानी के परिणामस्वरूप 12 प्रजातियों के जीवों के 988 नमूने एकत्र किए गए और ओ आइ ई में सूचीकृत रोगजनकों के लिए उनकी जांच की गई। हाल ही में केरल से रिपोर्ट की गयी हमलाकारी शंबु प्रजाति, *मिटेल्ला स्ट्रिगाटा* की भी पेरकिनसस संक्रमण के लिए जांच की गई और सकारात्मक थी। *पेर्ना विरिडिस, पेर्ना इंडिका, पिन्ना बाइकोलर, साकोस्ट्रिया कुकुल्लेटा, पाफिया मलबारिका, जेलोइना बेंगालेन्सिस* और *मिटेल्ला स्ट्रिगाटा* में *पी. ओलसेनी* को पाया गया।, पेर्ना, *पी. मलबारिका, जी. बेंगालेन्सिस, मोडियोलस मोडियोलस, साकोस्ट्रिया कुकुल्लेटा* और *एम. स्ट्रिगाटा* में *पी. बीहाएन्सिस* देखी गयी। *पी. मलबारिका, पी. विरिडिस, जी. बेगालेन्सिस, एम. मोडियोलस* और *एम. स्ट्रिगाटा* में मिश्रित संक्रमण देखे गए।

मात्स्यिकी और जलजीव पालन में एंटीमाइक्रोबियल प्रतिरोध (ए एम आर) की निगरानी करने वाली अनुसंधान परियोजना में, केरल और कर्नाटक में पिंजरों में पालन की गयी समुद्री मछलियों से *ई. कोली, विब्रियोस, स्टेफाइलोकोकस* को अलग किया गया। *ई. कोली* में सेफोडॉक्सिम, सेफोटॉक्सिम, एमिकासिन और इमिपेनेम के खिलाफ बहुत अधिक प्रतिरोध था। *स्टेफाइलोकोकस* में पेनिसिलिन जी के खिलाफ बहुत अधिक प्रतिरोध देखा गया।

मछली स्वास्थ्य पर अखिल भारतीय नेटवर्क परियोजना में, एक बायोडिग्रेडेबल सहायक के रूप में फुकोडियन का इन विट्रो और इन-विवो विश्लेषण पर प्रारंभिक अध्ययन किया गया। कासरगोड में शंबु पालन खेतों में आर्थिक नुकसान का मूल्यांकन किया गया और *पेर्ना विरिडिस* के हीमोलिम्फ और मैन्टिल तरल पदार्थ से संबंधित जैव रासायनिक और प्रतिरक्षात्मक मानकों पर मौसमी प्रभाव पर भी अध्ययन किया गया। परिवर्तित लवणता वाले परिस्थितियों पर मैंग्रोव रेड स्नापर *लूटजानस अर्जेन्टिमाकुलेटस* में तीव्र आयनिक-मॉड्यूलेटरी प्रतिक्रियाओं का

अध्ययन किया गया। एशियन हरा शंबु (*पेर्ना विरिडिस*) में ऊतक विशिष्ट स्वदेशी बैक्टीरिया घनत्व का अध्ययन किया गया, जिससे स्पष्ट रूप से स्वस्थ परिस्थितियों में हीमोलिम्फ सहित ऊतकों के गैर-बाँझ प्रकृति की पुष्टि की गयी।

समुद्री शैवाल से समुद्री पोषक तत्वों के विकास की विरासत को जारी रखते हुए समुद्री शैवाल से विकसित सी एम एफ आर आइ के 6 वीं कडलमीन™ एंटीहाइपरटेन्शनल एक्सट्रैक्शन (कडलमीन™ AHe) का विमोचन दिनांक 28 मई 2019 को भारतीय कृषि अनुसंधान परिषद के महानिदेशक डॉ. त्रिलोचन महापात्र द्वारा किया गया। जैव पूर्वेक्षण पर आगे के कार्यों में संभावित विरोधी संक्रामक एजेंटों के रूप में समुद्री शैवाल से जुड़े हेटेरोट्रोफ़ से मैक्रोसाइक्लिक लैक्टोन पर अनुसंधान शामिल है। 24-सदस्यीय मैक्रोसाइक्लिक लैक्टोन परिवार के तीन होमोलॉग सदस्यों, जिनके नाम बेकावलैक्टोन 1-3 हैं, जिनका असर 13-O-ethyl (1), 15-O-furanyl-13-O-isobutyl-7-O-प्रोपाइल प्रोपेनोएट (2), और 15-O-फुरान्यल-13-O-आइसोबूटाइल-7-O-प्रोपाइल प्रोपनोएट -7, 24-डाइमिथाइल (3) कार्यक्षमताओं को जैवसक्रियता-निर्देशित शुद्धि के माध्यम से हासिल किया गया। ग्रेसिलेरिया *सालिकोर्निया* से तीन ड्रिमेन सेस्क्विटेरपेन क्विनोलों को शुद्ध किया गया। समुद्री अर्चिन *स्टोमोप्न्यूस्टस वेरियोलेरिस* से प्रति सूजनकारी सेम्ब्रेन और स्टोमोप्लोलिडस का विलगन किया गया। समुद्री हेटरोट्रॉफिक *बासिलस* से बहु दवा प्रतिरोधी रोगजनकों के खिलाफ एंटीमाइक्रोबियल एजेंटों के रूप में ऑक्सीजनेटेड एलान्सोलिड प्रकार के मैक्रोलाइड्स को अलग किया गया। समुद्री शैवाल *हिपनिया वालेन्शिए* से एक हेटेरोट्रोफिक गामा प्रोटियोबैक्टीरियम को अलग किया गया। बक्किनिड जठरपाद मोलस्क *बेबीलोनिया स्पिरेटा* से एक ग्लाइकोसामिनोग्लाइकन-जाइलोपैरानन पूर्व-सूजनकारी 5-लिपोक्सिजेनेस को अलग किया गया। *एम्फियोक्टोपस नेग्लक्टस* से निकाले गए मैक्रोसाइक्लिक लैक्टोनेस को एंजियोटेंसिन – II प्रेरित कार्डियाक हाइपरट्रोफी (हृदय की मांसपेशियों का मोटा होना) को कम करने के लिए सहायक पाया गया।

मंडपम में पालन की गयी कोबिया मछली के अंगुलिमीनों (फिंगरलिंग्स) की औसत अतिजीविता दर 9% और पोम्पनो 23.5% थी। विशाखपट्टणम में नारंगी चित्तियाँ वाली ग्रूपर मछली की अतिजीवितता दर 12% थी। कारवार में *एकान्थोपाग्रस बेर्डा, ए. लेटस, लूटजानस अर्जेन्टिमाकुलेटस, एल. जोनी* और *सिगानस वेर्मिकुलेटस* का अंडशावक विकास किया गया। कालिकट में पुनःचक्रण जलजीव पालन प्रणाली (आर ए एस) के साथ संलग्न किए गए 5 टन धारिता वाले टैंक में *एकान्थोपाग्रस बेर्डा* में परीक्षणात्मक तौर पर अंडशावक विकास और प्रेरित प्रजनन किए गए। मद्रास अनुसंधान केन्द्र की स्फुटनशाला में इंडियन हालिबट *सेट्टोडस एरुमेई* के अंडशावक का अनुरक्षण करके इसके व्यवहार और अनुकूलन पर अध्ययन किया जा रहा है। मंडपम में कोबिया और सिल्वर पोम्पानो की प्रजनन जीवसंख्या का आनुवंशिक प्रबंधन किया जाता है। पालनकारों और अन्य हितधारकों को उच्च गुणता वाले बीज के उत्पादन के लिए कोबिया और सिल्वर पोम्पानो की अंडशावक जीवसंख्या में आनुवंशिक परिवर्तनशीलता पर निगरानी की जा रही है। क्रस्टेशियनों में, मद्रास केन्द्र में रेती महाचिंगट का बीज उत्पादन परीक्षण जारी है और मंडपम में *पेनिअस सेमीसल्केटस* का समुद्र रैंचन किया गया। खाद्य मछली और अलंकारी मछली दोनों मछली के बीज की बिक्री के माध्यम से, मंडपम केन्द्र ने 14.6 लाख रुपये का राजस्व उत्पन्न किया। विषिंजम में कलनोइड कॉपीपोड *एकार्टिया साउथवेल्ली, पारवोकलानस क्रास्सिरोस्ट्रिस, बेस्टियोलिना सिमिलिस, स्यूडोडयाप्टोमस सेरीकॉडेटस और टेमोरा टर्बिनेटा, साइक्लोपोइड कॉपीपोड ओइथोना ब्रेविकोर्निस, डयोथोना ओकुलेटा,* और हारपाक्टिकोइड कॉपीपोड *यूटेरपिना ऑटिफ्रोन्स* का नियमित रूप से अनुरक्षण किया जा रहा है। विशाखपट्टणम केन्द्र में पारवोकलानस का व्यापक मात्रा में उत्पादन और नानोक्लोरोप्सिस शैवाल सांद्र के नयाचार का मानकीकरण किया गया। स्वास्थ्य प्रबंधन उपाय के रूप में, कोबिया अंडशावकों में, बहु टीकाकरण का उपयोग करके बड़े पैमाने पर रोग-प्रतिरक्षा के परिणामस्वरूप बेहतर प्रतिरक्षा हुई। मंडपम में हानिकारक शैवाल फुल्लन (एच ए बी) के फलस्वरूप कोबिया के कई अंडशावक मछलियों की मृत्यु हुई। *नोक्टिलूका सिन्टिल्लन्स* को हानिकारक शैवाल के रूप में पहचाना गया था। ट्राइकोडिनियासिस कोबिया हैचरी में पाए जाने वाला सबसे तीक्ष्ण एक्टोपारासाइट है, जो रसायनों और प्रतिरक्षा उत्तेजकों (इम्युनोस्टिम्युलेंट) दोनों का उपयोग करके प्रबंधित किया गया। विषिंजम मे हरा शंबु बीज के लिए स्थापित माइक्रो-नर्सरी, बीज रोपित रस्सियों की बिक्री के साथ आगे बढ़ी। हमारे विषिंजम केंद्र में एन एफ डी बी वित्त पोषित समुद्री मछली ब्रूड बैंक पूरी तरह कार्यरत हो गया।

समुद्रीसंवर्धन के क्षेत्र में, पिंजरों में एंटीफाउलिंग एजेंटों के उपयोग पर यह संकेत दिया गया कि वाणिज्यिक रूप से उपलब्ध एंटीफाउलिंग कोटिंग, TORPEDO, कुप्रस ऑक्साइड और कार्बनिक बायोसाइड्स के साथ विनाइल एंटीफाउलिंग पेंट, खरपतवार, कवच और पशु फाउलिंग के लिए लंबे समय तक प्रतिरोध के रूप में सक्रिय रूप में, बायोफाउलिंग को काफी कम कर देते हैं। पिंजरों में ~ 85 ग्राम ~ 338 ग्राम के शुरुआती वजन वाले झींगों के पालन से प्रति किलोग्राम के लिए 2000 रुपये का फार्म गेट मूल्य प्राप्त हुआ। कोबिया और समुद्री शैवाल के एकीकृत बहु पौष्टिक जलजीव पालन (आइ एम टी ए) से 1.105 टन मछली और 19.2 टन समुद्री शैवाल की उपज प्राप्त हुई। नारंगी चित्तियों वाली ग्रूपर के अंगुलिमीनों में एक दिन में 3, 4 और 6 बार अलग-अलग फीडिंग आवृत्ति पर किए गए अध्ययनों से पता चला है कि दिन में 4 बार खिलाए गए अंगुलिमीनों ने 300 और 400 / एम 3 के संभरण घनत्व पर बेहतर प्रदर्शन दिखाया। जब भारतीय पोम्पानो के अंगुलिमीनों को आर ए एस नर्सरी में पालन किया गया, तो दो महीने

में 0.5 ग्राम से 8 ग्राम तक की वृद्धि हासिल की जा सकी। तालाब में नारंगी चित्तियों वाली ग्रूपर मछली का पालन किए जाने पर 330 दिनों तक के पालन से 1.5 किलोग्राम शरीर भार तक बढ़ गयी। इन विट्रो और प्रायोगिक अध्ययनों में मल्टीवैलेंट वाइब्रोसिस वैक्सीन के मानकीकरण के बाद, पिंजरे में पालन की गयी कोबिया में किए गए क्षेत्र अनुप्रयोग परीक्षणों से पता चला है कि हर वर्ष जुलाई से सितंबर (मानसून-पूर्व मौसम) के महीनों के दौरान पिंजरे में रहने वाली कोबिया में नियमित रूप से एपिज़ूटिक्स देखा गया और टीकाकरण द्वारा सफल रूप से रोका गया। मंडपम में, कोबिया मछली में पहली बार इंटेरेक्स गोनाड्स देखे गए जो मुख्य रूप से गोनोकोरिस्टिक हैं। सी एम एफ आर आइ विषिंजम अनुसंधान केन्द्र में स्थापित पोम्पानो ब्रूड-बैंक तीन भवनों, जो कि प्रयोगशाला सह शैवाल-संवर्धन इकाई, आर ए एस भवन और हैचरी भवन के निर्माण के बाद इस वर्ष कार्यरत हुआ। शंबु पालन के विकल्प के रूप में, पालनकारों को शुक्ति पालन करने के लिए प्रोत्साहित किया गया और कन्नूर जिले के पुंजक्क्कड़ और कासरगोड जिले के ओरी में किसानों को प्रशिक्षण दिया गया।

समुद्री संवर्धन में अखिल भारतीय नेटवर्क परियोजना (ए आइ एन पी) के अंतर्गत विषिंजम में बैंडेड ग्रंटर (*पोमाडासिस फरकेटस*) का ब्रूड स्टॉक विकास का प्रयास किया जाता है। विषिंजम हैचरी में वर्ष के स्वैच्छिकअंडजनन से प्राप्त पिंक इयर एम्पोरर मछली (*लेथ्रिनस लेन्जन*) के अंडों का नियमित रूप से समुद्र रैंचन किया जाता है। मार्सिया की एंथियस, *स्यूडान्थियास मारसिया*, बहुत आकर्षक और अत्यधिक कीमत वाली सजावटी मछली है, का प्रग्रहण स्थितियों के तहत विजिंजम में स्वैच्छिक रूप से अंडजनन हुआ। विभिन्न पारिस्थितिक तंत्रों में पालन किए जाने पर सिल्वर पोम्पानो मछली की वृद्धि में भिन्नता देखी गयी। पिंजरों में रैबिट फिश, करंजिड्स, नारंगी चित्तियों वाली ग्रूपर, रेड स्नाप्पर, पोम्पानो, और एशियन समुद्रीबास का पालन इस परियोजना का प्रमुख कार्य रहा। झींगा पालन तालाबों में सिल्वर पोम्पानो का पालन करने की व्यवहार्यता का परीक्षण किया गया और व्यवहार्य पाया गया। गुजरात तट पर समुद्री संवर्धन के लिए संभावित स्थानों की पहचान के लिए जी आइ एस आधारित स्थानिक प्रतिमान भी पूरा किया गया। अनुसूचित जाति उप-योजना परियोजना के अंतर्गत कई प्रशिक्षण कार्यक्रम और समुद्री संवर्धन गतिविधियों का आयोजन भी किया गया।

भारतीय तट पर जैविक रूप से संवेदनशील क्षेत्रों के लिए संरक्षण योजनाओं को विकसित करने की परियोजना में, महाराष्ट्र में धर्मातर, दाभोल, कलबादेवी और बंगकोट संकरी खाड़ियों की जैव विविधता की निगरानी की गई। कर्नाटक में मुल्की, प्रिमेयरिया और काउप चट्टान पारिस्थितिक तंत्र, केरल में कडलुंडी, कोरप्पुषा, तिक्कोडी, कोलाविपालम और धर्मडम मुहाने, पुन्नकयाल और पालयकायल के मुहाने, बारहमासी नदी तामराबरनी, मनकुडी मुहाना, तमिलनाडु में नागापट्टिनम जिले में कोरोमंडल तट पर एक कम प्रोमोटरी पर स्थित कैलीमेरे वन्यजीव और पक्षी अभयारण्य, मुहाना, खुले समुद्र, मैंग्रोव, पश्चजल और संकरी खाड़ी के रूप में विशेषित भैरवपालम, आंध्रा प्रदेश में विशाखपट्टणम का पुदिमडका मत्स्यन गाँव जैव विविधता की विशेषता वाले स्थान हैं, इन स्थानों की निगरानी भी की गई।

भारतीय तट पर स्काइफ़ोज़ोन और क्यूबोज़ोआन जेलीफ़िश विविधता और वितरण पर जांच के परियोजना में, जेली-फिश जैव विविधता का दस्तावेजीकरण करने के अलावा, भारतीय समुद्र से गूढ़ जेलीफ़िश, *क्रैंबियोनेला अन्नन्डाली* (निडेरियाः साइफोज़ोआ) का पुन: वर्णन किया गया। भारत की प्रवाल भित्तियों की लचीलापन क्षमता के आकलन में, अंडमान के हैवलॉक और नील द्वीपों पर सर्वेक्षण किए गए। कावरत्ती द्वीप समूह के रीफ फ्लैट्स और समान चट्टानों में अंडरवाटर सर्वेक्षण का आयोजन किया गया और उत्तरी अगत्ती क्षेत्र में कठोर प्रवालों पर एनीमोन की व्यापक वृद्धि का संकेत मिला। अमीनी द्वीप समूह में पिंगलाइन रोगलक्षण के साथ रोग की घटनाएँ प्रचलित थीं।

भारतीय तट के शंकुश (शंकु घोंघे) और स्ट्रोम्बस (मोलस्का, गैस्ट्रोपोडा) के आणविक वर्गीकरण और फाइलोजेनी में, अंडमान और निकोबार द्वीप समूह सहित भारत के दोनों तटों के नौ नमूना स्थानों से 20 प्रजातियों (57 जीव) को संग्रहित किया गया। एकीकृत वर्गीकरण से अंडमान और लक्षद्वीप द्वीपसमूह के कॉनस (पिनोकोनस) कैटस में असाधारण फीनोटिपिक प्लास्टिसिटी व्यक्त हुआ। कडलुंडी-वल्लिकुन्नू सामुदायिक रिजर्व (के वी सी आर), जिसे अक्टूबर 2007 में घोषित किया गया था, केरल का पहला सामुदायिक रिज़र्व है और यह भागिक रूप से राज्य के कोषिकोड और भागिक रूप से मलप्पुरम जिलों में स्थित है। 153.84 हेक्टेयर का कुल क्षेत्र होने वाले कम्युनिटी रिजर्व में मैंग्रोव, मिट्टी के फ्लैट और समृद्ध जैव विविधता की विशेषता है। इस परियोजना को के वी सी आर की जैव विविधता का दस्तावेजीकरण करने और इस आर्द्रभूमि द्वारा प्रदान की गई विभिन्न पारिस्थितिकी प्रणालियों की सेवाओं के मूल्य को चित्रित करने की परिकल्पना की गई। अध्ययनों के आधार पर कई प्रबंधन उपाय सामने आए हैं और केरल राज्य जैव विविधता बोर्ड (के एस बी बी) को मुहानों से रेत निकालने, मैंग्रोव का रोपण करने, मैंग्रोव नर्सरी बनाने, स्थानीय लोगों को क्षमता निर्माण और एक व्याख्या केंद्र के निर्माण का सुझाव दिया गया। भारत के कम ज्ञात समुद्री जानवरों के वर्गीकरण संबंधी अन्वेषण -फाइलम निडेरिया (क्लास: एंथोज़ोआ) और फाइलम: पोरिफ़ेरा (समुद्री) भी आयोजित किया गया।

पारिस्थितिकी तंत्र स्वास्थ्य और स्थायी उत्पादन के लिए चयनित महत्वपूर्ण आवासों के लिए सूक्ष्म-स्तरीय पर्यावरण प्रबंधन योजनाओं पर अनुसंधान परियोजना में, विकसित पारिस्थितिकी तंत्र स्वास्थ्य सूचकांक (ई एच आइ) का उपयोग मानसून, प्री-मानसून और मानसून के मौसम के दौरान चयनित तटीय पारिस्थितिकी तंत्र की निगरानी के लिए किया गया। टिकाऊ सूक्ष्म-स्तरीय पर्यावरण प्रबंधन

योजनाओं (ई एम पी) के विकास के लिए गुजरात में पारिस्थितिकी तंत्र स्वास्थ्य के लिए मैंग्रोव और समुद्री घास संस्तर जैसे संवेदनशील आवासों का मूल्यांकन किया गया। मंडपम में मैंग्रोव नर्सरी प्रबंधन के लिए भागीदारी नयाचार विकसित किया गया।

मछली पालन और समुद्री संवर्धन पर विशेष ज़ोर देने के साथ पारिस्थितिकी तंत्र पर काम कर रहे जलवायु चरम सीमाओं और आपदाओं के प्रभाव पर परियोजना में उष्णकटिबंधीय चक्रवात के कारण पारिस्थितिक प्रणाली पर आधारित परिवर्तन कम थे और सामाजिक-आर्थिक प्रभाव अधिक था और अप्रत्याशित चरम घटनाओं के लिए मछुआरों की तैयारियों को बढ़ाने के लिए चेतावनी और पोत ट्रैकिंग प्रणाली को विकसित करने की आवश्यकता है। जैव उपचार के माध्यम से तटीय प्रदूषण के उन्मूलन के लिए, किए गए परीक्षणों से यह संकेत मिला कि समुद्र के एसिड के प्रतिकूल प्रभाव को और अधिक प्रभावी ढंग से कम करने के लिए समुद्री तट पर समुद्री शैवाल के लिए अधिक आवासों की पुनःस्थापना और समुद्री शैवाल का बड़े पैमाने पर समुद्री संवर्धन करने की तत्काल आवश्यकता है। मैंग्रोव और अन्य जलीय पौधों पर भारी धातुओं और अमोनिया विषाक्तता के प्रभाव का अध्ययन किया गया और यह स्थापित किया गया कि कैसे कोच्ची के पश्चजल में औद्योगिक अपशिष्ट के साथ फेंके गए भारी धातु इन महत्वपूर्ण जैव बाड़ को नुकसान पहुंचा सकते हैं। शीर्षपाद प्रसंस्करण प्लांट के अपशिष्ट जल में पाए जाने वाले कैडमियम का आइकोर्निया क्रास्सिपेस पौधों का उपयोग करके जैव उपचार किया गया।

भारत के चुने गए समुद्रवर्ती राज्यों में तटीय और समुद्री प्रदूषण के आकलन में, एरणाकुलम जिले में चयनित मैंग्रोव पारिस्थितिकी प्रणालियों के तलछट में सूक्ष्म और मध्यम प्लास्टिक संदूषण के स्तर में अनुमानित मौसमी भिन्नता, माइक्रोप्लास्टिक के उच्च स्तर को दर्शाती है। पश्चिमी तट के कोचीन, रत्नागिरि, मुंबई और वेरावल के साथ-साथ भारत के पूर्वी तट के विशाखपट्टणम से मछली पकड़ने की मात्रा में समुद्री प्लास्टिक कूड़े (एम पी एल) और इसके सापेक्ष प्रतिशत में स्थानिक और कालिक विविधताओं का आकलन किया गया।

भारत में समुद्री मैक्रोफाइट्स पर परियोजना में–संसाधन, गतिकी और पारिस्थितिक तंत्र सेवाएं, कडलुंडी मुहाने में देखे गए समुद्री घास हालोफिला संस्तर के सामने आने वाले प्रमुख खतरों में से एक है मुहाने के पास रेत संस्तर का गठन और समुद्री घास संस्तर की ओर इसका और विस्तार और इससे संभाव्य आवास का क्षरण।

भारत के दक्षिण पूर्वी तट पर समुद्री संवर्धन के माध्यम से लाल समुद्री शैवाल *कापाफाइकस अलवारेज़ी* का उत्पादन में 350 से 1250 टन सूखे भार के रूप में अनुमानित किया गया। पानायिकुलम और मुनैकाडु तटों पर समुद्री घास प्रत्यारोपण पर प्रयोगात्मक अध्ययन किए गए। पाक खाड़ी के समुद्री घास मैदानों का ब्लू कार्बन स्टॉक 0.00177 TgCe / वर्ष (कार्बन डाइऑक्साइड के बराबर) तक निर्धारित किया गया था और मन्नार की खाड़ी में यह 0.04395 TgCe / वर्ष का अनुमान लगाया गया। देवीपटिणम के पास तोप्पुकाडु मैंग्रोव क्षेत्र में स्थानीय मछुआरों की सहभागिता से एक मैंग्रोव नर्सरी (*सेरियॉप्स टागल, राइज़ोफोरा मुक्रोनेटा, अविसीनिया मरीना* और *पैम्फिस एसिडूला*) विकसित किया गया।

जलवायु परिवर्तन के क्षेत्र में, स्मूथ ब्लासोप *लागोसेफालस इनेर्मिस* के ओटोजेनिटिक और मौसमी विविधताओं का अध्ययन किया गया। क्लस्टर विश्लेषण का उपयोग करके आहार के मौसमी विश्लेषण किए जाने पर पता चला कि अधिकतम समानता प्री-मानसून और मानसून के बीच की थी जिसमें मानसून जुड़ा हुआ था। SIMPER विश्लेषण से पता चला है कि मानसून पूर्व, पश्च-मानसून और मानसून के बीच असमानता में योगदान देने वाली प्रमुख चारा *सॉरीडा* प्रजाति और केकड़े थी, जबकि झींगा और एपोगोन प्रजाति ने मानसून और मानसून के बाद की असमानता में योगदान दिया। कई सहसंबंध विश्लेषण और रेखीय प्रतिगमन मॉडल के साथ भारत के दक्षिण-पश्चिमी तट की तारली और बांगड़ों की शरीर के आकार पर निर्भर प्रतिक्रिया और भोजन आदतों पर अध्ययन किए जाने पर भारतीय बांगड़ा (*रास्ट्रेलिगर कानागुर्टा*) और भारतीय तारली (*सार्डिनेल्ला लोंगिसेप्स*) की औसत लंबाई में SST (1960-2016) और SSC (1998-2016), प्री-मॉनसून (फरवरी-मई) के लिए सबसे अधिक प्रभाव के साथ समुद्री सतह का तापमान (SST) और पोस्ट-मॉनसून (अक्टूबर से जनवरी) समुद्री सतह ठंडा (SSC) होने के अनुसार महत्वपूर्ण बदलाव का संकेत देखा गया। जलवायु परिवर्तन प्रतिमान में, छोटे पेलाजिक मात्स्यिकी पर महासागरीय चालकों का प्रभाव अध्ययन करने पर यह पाया गया कि, दक्षिण-पश्चिम तट के साथ प्रमुख छोटे पेलाजिक मात्स्यिकी, मौसमी रूप से होने वाली अपवेलिंग और डाउनवेलिंग घटना और युग्मित महासागर-वायुमंडल की गतिशीलता पर निर्भर करती है। भारतीय तटीय क्षेत्रों में क्लोरोफिल सांद्रता पर स्थानिक-कालिक विविधताओं का विश्लेषण करने पर, दो दशकों के संचयी रुझान से पता चलता है कि दक्षिण-पूर्व क्षेत्र में मानसून के मौसम में क्लोरोफिल की बढ़ती प्रवणता थी, जबकि अन्य क्षेत्रों में सभी मौसमों में घटती की बढ़ती प्रवणता दृश्यमान थी। जलवायु परिवर्तन के प्रति मात्स्यिकी और गियर भेद्यता के अंतर्गत, विभिन्न रेप्रेसेन्टेटीव कान्सेन्ट्रेशन पाथवे (आर सी पी) परिदृश्यों के तहत मात्स्यिकी और फसल संग्रहण तरीकों की भेद्यता में परिवर्तन की भविष्यवाणी की गई है, जिससे पता चलता है कि दोनों क्षेत्रों में गियर की भेद्यता और मात्स्यिकी भेद्यता वर्तमान फसल संग्रहण रणनीतियों के अनुसार बढ़ती हैं। अंतरिक्ष अनुप्रयोग केंद्र (एस ए सी) – आइ एस आर ओ द्वारा परियोजना की आवश्यकता के अनुसार वैज्ञानिक समुदायों तक पहुंच के साथ एक वेटलैंड मोबाइल एप्लिकेशन और संबंधित वेबसाइट विकसित और परिचालन मैनुअल के साथ स्थानांतरित किया गया। क्लाइमेट स्मार्ट विलेज (CSV) विकास और भेद्यता मूल्यांकन के अंतर्गत, 21 तटीय गांवों का मूल्यांकन किया

गया। सामाजिक-आर्थिक और पारिस्थितिक लचीला रणनीति के रूप में जलवायु क्लब तटीय लचीलापन बढ़ाने के लिए जलवायु क्लबों में इस तरह के पहले नेटवर्क का नेतृत्व करते हैं।

आर्थिक स्थिरता और व्यापार में, मछली के अवतरण केंद्र स्तर और खुदरा स्तर पर समुद्री मछली अवतरण का मूल्यांकन किया गया। आंध्रा प्रदेश, गोवा, गुजरात, कर्नाटक, केरल, महाराष्ट्र, ओडीषा, पुदुचेरी, तमिल नाडु, पश्चिम बंगाल और दमन और दीव के लिए मूल्य श्रृंखलाओं में राज्य-वार मूल्यांकन किया गया। प्रजातिवार मूल्यांकन भी किया गया। राष्ट्रीय स्तर पर मैक्रो आर्थिक संकेतक, कुल परिचालन लागत 34,702.24 करोड़ रुपए और शुद्ध परिचालन आय 261,78.89 करोड़ रुपए थे। औसत पूँजी उत्पादकता 0.57 थी और समुद्री मत्स्य क्षेत्र में जोड़े गए सकल मूल्य का अनुमान 40,790.36 करोड़ रुपए था, जो सकल राजस्व का 67 प्रतिशत था। मछली पकड़ के तरीकों के आर्थिक प्रदर्शन से संकेत मिला कि, गैर-यंत्रीकृत बॉटम सेट गिलनेट (0.42) के मामले में सभी पूंजी उत्पादकता बहुत अधिक सक्षम थी। यह कर्मी दल के वेतन के कम अनुपात के कारण है क्योंकि अधिकांश गैर-यंत्रीकृत इकाइयां केवल पारिवारिक श्रम द्वारा संचालित की जाती हैं। तमिलनाडु के तुत्तूर में स्थित गहरा-सागर मत्स्यन उद्योग की मछली पकड़ने और मूल्य श्रृंखलाओं का एक आर्थिक विश्लेषण भी प्राथमिक सर्वेक्षणों के आधार पर किया गया। वर्ष 2019 के लिए प्रमुख प्रजातियों के लिए अवतरण केंद्र की कीमतों के राज्य-वार मूल्य व्यवहार पर भी अध्ययन किया गया। राज्यों में समुद्री मछली बाज़ार की दक्षता और पूरे भारत में समुद्री मछली की खपत के प्रतिमान और स्थानिक मांग पर भी काम किया गया। भारतीय मात्स्यिकी क्षेत्र में ई-विपणन हस्तक्षेप और भारतीय मात्स्यिकी क्षेत्र के लिए एक एकीकृत मछली बाज़ार और मूल्य सूचना प्रणाली (एफ एम पी आइ एस) का विकास, 1000 मछली बाज़ारों का नमूना प्रगति पर है। मछली, बाज़ार, मूल्य सूचना प्रणाली और ई-नीलामी जैसे चार डोमेन को दिखाने वाला एक वेब पोर्टल एन एफ डी बी के सहयोग से विकसित किया गया। एफ एम पी आइ एस परियोजना के डेटा संग्रह के लिए टैबलेट के लिए विकसित सॉफ्टवेयर में शामिल करने हेतु भारत के विभिन्न मछली बाजारों में विपणन की जाने वाली 150 मछली प्रजातियों, जिन में 120 समुद्री प्रजातियाँ और 30 अंतर्देशीय प्रजातियाँ हैं, के साथ एक फील्ड मैनुअल, मछलियों के सामान्य नामों, वैज्ञानिक नामों और विभिन्न तटीय क्षेत्रों में स्थानीय नामों के साथ विकसित किया गया। उत्तरदायित्वपूर्ण समुद्री मात्स्यिकी शासन के अंतर्गत: अनुपालन विश्लेषण और समतामूलक क्षमता विकास परियोजना, केरल के समुद्री मात्स्यिकी नियमों, अनुपालन स्थिति और संज्ञानात्मक कमियों, जिसमें मछुआरों के बीच क्षमता विकास (सी डी) हस्तक्षेप की आवश्यकता होती है, पर सामान्य धारणा के बारे में जानने के लिए अध्ययन किया गया। केरल सरकार के मात्स्यिकी विभाग के सहयोग से विभिन्न स्थानों पर समतामूलक क्षमता विकास विचार-विमर्श का आयोजन किया गया। कम होने वाली मछली संपत्ति के संरक्षण के लिए मछली पकड़ की अवैध गतिविधियों पर पूर्ण रोक लगाना बहुत आवश्यक है। इसी प्रकार, सुनिश्चित अनुपालन (46.8%) के साथ विनियमों और नियमों का कड़ाई से कार्यान्वयन और मछली पकड़ने की अवधि (12. 8%) बढ़ाना टिकाऊ तरीके से मछली स्टॉक संसाधनों की रक्षा करने के लिए रिंग सीन मछुआरों द्वारा सुझायी गयी अन्य दो महत्वपूर्ण रणनीतियाँ थीं।

भारत के समुद्री मात्स्यिकी क्षेत्र में उद्यमशीलता विकास के लिए विविध आजीविका विकल्पों और लिंग मुख्यधारा पर शोध परियोजना में, तमिलनाडु के रामनाथपुरम जिले में मात्स्यिकी / गैर- मात्स्यिकी से संबंधित विविध आजीविका (डी एल ओ) के प्रलेखन के लिए व्यापक क्षेत्र सर्वेक्षण किए गए। छोटे पैमाने की कवच प्रसंस्करण इकाइयों की उच्चतम औसत वार्षिक आय की सीमा 7,86,600 रुपये तक थी। यह व्यापक रूप से रामेश्वरम जिले के, पंबन, तोंडी और कीलाकरै क्षेत्रों में 342 मानव कार्य दिवस प्रचलित हैं। वेदालै, रामेश्वरम, कीलाकरै और सोलियाकुडी के नाव बनाने वाले मछुआरों द्वारा भी इसका अनुपालन किया जा रहा है। यंत्रीकृत और मोटर चालित दोनों युक्त नाव निर्माण इकाइयों के मालिकों की औसत वार्षिक आय 319 मानव-दिनों के काम के लिए 5,42,400 रुपए थी। गैर- मात्स्यिकी क्षेत्र के अंतर्गत, मछुआरों को पनई के पत्तों से चटाई बनाने से 180 दिनों के रोजगार के दौरान 66,000 रुपए की उच्चतम वार्षिक आय प्राप्त होती है। जिले के तामरैकुलम और मुत्तुपेटै स्थानों में पनई के पत्तों से चटाई निर्माण किया जाता है। यह देखा गया कि मात्स्यिकी / गैर-मात्स्यिकी संबंधित सभी उद्यम अकेले उद्यम हैं। मछुआरिनों के लिए वैकल्पिक आजीविका के विकल्प प्रदान करने की परिकल्पना किए गए *तीरामैत्री* कार्यक्रम में आर्थिक रूप से व्यवहार्य इकाइयों के लिए प्रभावी प्रभावशीलता और प्रभावी कार्यान्वयन सुनिश्चित करने के लिए एक सार्वजनिक, पंचायत, व्यावसायिक भागीदारी (पी पी पी पी) मॉडल, रोड मैप विकसित किया गया। *तीरानैपुण्या* प्रशिक्षण कार्यक्रम के बाद नौकरियों के लिए खोजे गए प्रशिक्षुओं में से 83.5 प्रतिशत को विभिन्न संगठनों में नौकरियां मिलीं, जिनमें निजी फर्म और सरकारी एजेंसियां शामिल थीं। *तीरानैपुण्या* प्रशिक्षण प्राप्त प्रशिक्षणार्थियों को नौकरी प्रदान किए गए जिलों की तुलना करने पर यह ज्ञात हुआ कि एरणाकुलम जिले में 67.30 % प्रशिक्षणार्थियों को नौकरी प्रदान की गयी और इसके बाद कोषिक्कोड जिला आता है (50.00%)। उपग्रह आधारित महासागर सूचना सेवाओं पर मछुआरों के कल्याण प्रभाव का आकलन: एक मूल्यांकन, एक अन्य परियोजना है जहां आइ एन सी ओ आइ एस द्वारा उपग्रह सूचना पूर्वानुमान के 2586 नमूने उत्तरदाताओं (1474 उपयोगकर्ता और 1112 गैर-उपयोगकर्ता) पर डेटा विश्लेषण पूरा किया गया था और परिणाम प्रस्तुत किए गए। ए टी आइ सी में 5608 छात्रों और 1377 उद्यमियों ने दौरा किया और सी एम एफ आर आइ के उत्पादों की बिक्री और सेवाओं के माध्यम से 7,05,985 रुपये का राजस्व उत्पन्न किया।।

Major Achievements

Minimum legal size proposed for commercially exploited marine finfish and shellfish resources off Tamil Nadu (113 species) & Maharashtra (58 species) has been prepared and published

A policy brief on management plan for marine fisheries of Tamil Nadu was prepared based on the comprehensive study conducted by CMFRI in the region

Non-determinant findings documents have been published for silky shark and thresher sharks for the Indian Ocean

Policy advisory and guidance for Good Mussel Farming Practices in India has been prepared and communicated to Kerala Fisheries Department for implementation

Advisories on the precautions, swarming seasons and usage of CMFRI Jellysafe kits were prepared

CMFRI closed the life cycle of one food fish Siganus Vermiculatus (Rabbit fish) and two more marine ornamentals - *Pseudanthias squamipinnis* (Sea goldie or Lyretail coralfish) and *Dascyllus melanurus* (Four stripe damselfish) leading to their seed production in captivity

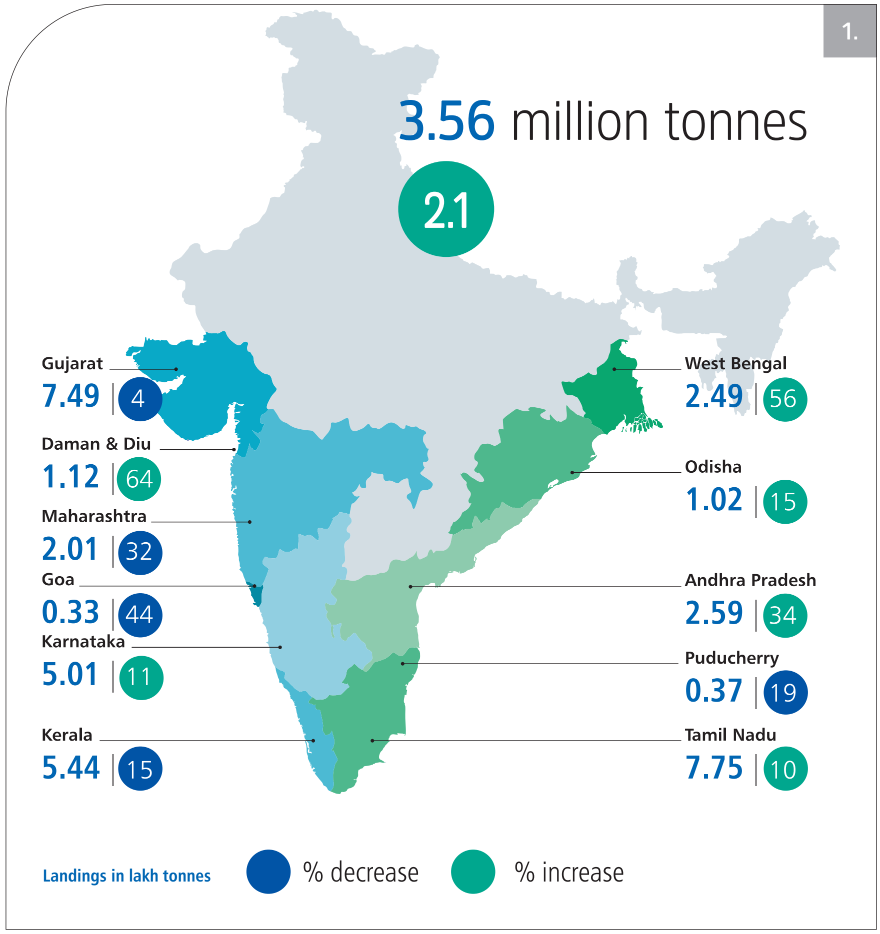
National Mariculture Policy 2019 (NMP2019) submitted to DoF/NFDB

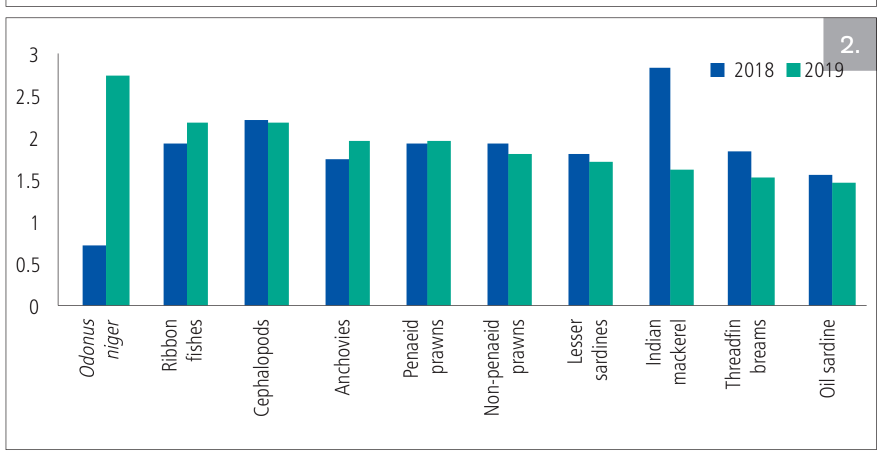
Working Group 3 Report [Fisheries, Aquaculture and Fish Processing] for developing a road map to Blue Economy of India was submitted to the Economic Advisory Council to the Prime Minister (EAC-PM)

Two marine food fish brood banks were made functional at Mandapam in Tamil Nadu and Vizhinjam in Kerala with National Fisheries Development Board's (NFDB) assistance

Fishery Resource Monitoring

Odonus niger landings





Fish Harvests

(Research Project: FRA/GIS/01)

Information on different aspects of marine fisheries during the year 2019 was collected online through the recently implemented online data collection system termed as the "Fish Catch Survey and Analysis (FCSA)" online data collection system. The scientific sampling methodology devised by the institute known as "Stratified Multistage Random Sampling Design (SMRSD)" was ensured during online data collection covering all the 1265 landing centres in all the 75 fishing zones in the nine maritime states and 2 union territories of the main land of India. For the state of Kerala the joint online data collection under FCSA involving state fisheries department staff was continued. The estimates of landings for 2019 was made at species level resolution, indicating the distribution along fishing zones as well as fishing gear type. Consolidation at district level, state level and national level were also carried out. Few prominent features observed in the fishery during 2019 are shown in the figures.

The estimate of marine fish landings at national level for the year 2019 is 3.56 million tonnes. In comparison to 3.49 lakh tonnes in 2018, the marginal increase is about 73,770 tonnes (2.1%). First time Tamil Nadu reached the top position with regard to total landings pushing down Gujarat to second position, which was in the first position for the past few years, with 7.75 lakh tonnes compared to 7.02 lakh tonnes in 2018 (10.4% increase) accounting for 21.7% of the total landings in India. The harvest from Gujarat in 2019 is 7.49 lakh tonnes (21.0% of national total) showing reduction of 4.0% compared to 7.80 lakh tonnes in 2018. Kerala remained at

1. Marine Fish Landings in India 2019
2. All India landings of Major Resources (in lakh tonnes)

third position with harvest of 5.44 lakh tonnes (15.3% of national total) even though there is reduction in landings by about 0.99 lakh tonnes (15.4%).

Increased landings in 2019 compared to 2018 were seen in West Bengal (by 88,800 tonnes), Tamil Nadu (by 72,700 tonnes), Andhra Pradesh (by 65,500 tonnes), Karnataka (by 49,300 tonnes), Daman & Diu (by 43,500 tonnes) and Odisha (by 13,000 tonnes). States/ UT with reduced landings are Kerala (by 98,700 tonnes), Maharashtra (by 94,400 tonnes), Gujarat (by 31,000 tonnes), Goa (by 26,200 tonnes) and Puducherry (by 85,000 tonnes).

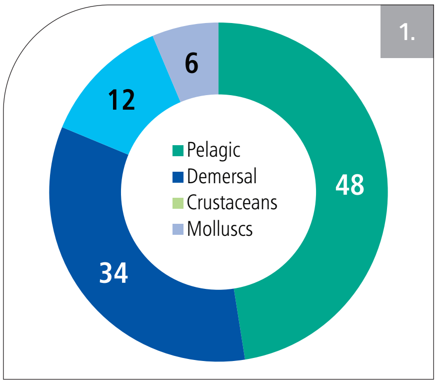
A notable feature of 2019 fishery is the popping up of *Odonus Niger*, a commercially less important marine fish, at national level as the major resource in the harvests with 2.74 lakh tonnes landings from only 72,140 tonnes in 2018. The other resources with high landings are ribbon fish (2.19 lakh tonnes), followed by penaeid prawns (1.95 lakh tonnes), non-penaeid prawns (1.80 lakh tonnes), lesser sardines (1.71 lakh tonnes), Indian mackerel (1.66 lakh tonnes), threadfin breams (1.53 lakh tonnes) and oil sardine (1.45 lakh tonnes).

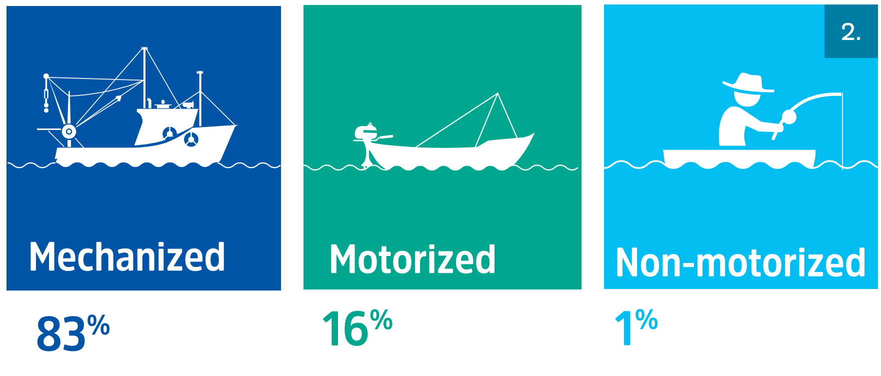
In 2019, out of the total 3.56 million

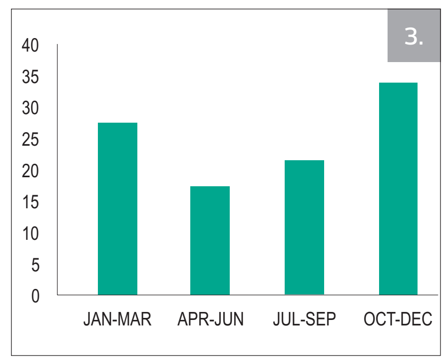
Estimated marine fish landings (tonnes) in India 2019

PELAGIC FINFISH		DEMERSAL FINFISH	
CLUPEOIDS		ELASMOBRANCHS	
Wolf herring	16899	Sharks	16174
Oil sardine	145083	Skates/Guitarfish	4281
Lesser sardines	170298	Rays	23281
Hilsa shad	14748	Eels	12321
Other shads	11290	Catfishes	65007
Anchovies		Lizard fishes	91144
Coilia	35178	PERCHES	
Setipinna	11016	Rock cods	26508
Stolephorus	105915	Snappers	10246
Thryssa	43334	Pig-face breams	11565
Other clupeids	80603	Threadfin breams	153066
Bombayduck	117213	Bullseyes	38789
Half Beaks&Full Beaks	5838	Other perches	56929
Flying Fishes	1989	Goatfishes	22705
Ribbon Fishes	218736	Threadfins	9074
CARANGIDS		Croakers	135750
Horse mackerel	48365	Silverbellies	100613
Scads	73816	Whitefish	4837
Leather-jackets	14001	POMFRETS	
Other carangids	130439	Black pomfret	16022
MACKERELS		Silver pomfret	28606
Indian mackerel	161957	Chinese pomfret	6599
Other mackerels	3269	FLAT FISHES	
SEER FISHES		Halibut	2275
Scomberomorus commerson	29396	Flounders	11
Scomberomorus guttatus	16279	Soles	47727
Scomberomorus lineolatus	33	*Odonus niger*	273705
Acanthocybium solandri	618	CRUSTACEANS	
TUNNIES		Penaeid prawns	194618
Euthynnus affinis	31843	Non-penaeid prawns	180103
Auxis spp.	12947	Lobsters	1671
Katsuwonus pelamis	31014	Crabs	56198
Thunnus tonggol	5853	Stomatopods	8602
Thunnus albacares	26177	MOLLUSCS	
Other tunnies	556	Mussels, Oysters & Clams#	110317
Bill Fishes	14765	Bivalves	3945
Barracudas	34010	Gastropods	4807
Mullets	14437	Cephalopods	
Unicorn Cod	92	Squids	112727
OTHERS		Cuttlefish	92849
Seaweed #	18400	Octopus	12123
MISCELLANEOUS	108498		
TOTAL			3690100

#The estimates are based on an alternate method and are excluded from the comparisons made. The comparisons are based on 3561383 tonnes (3690100-110317-18400=3561383)







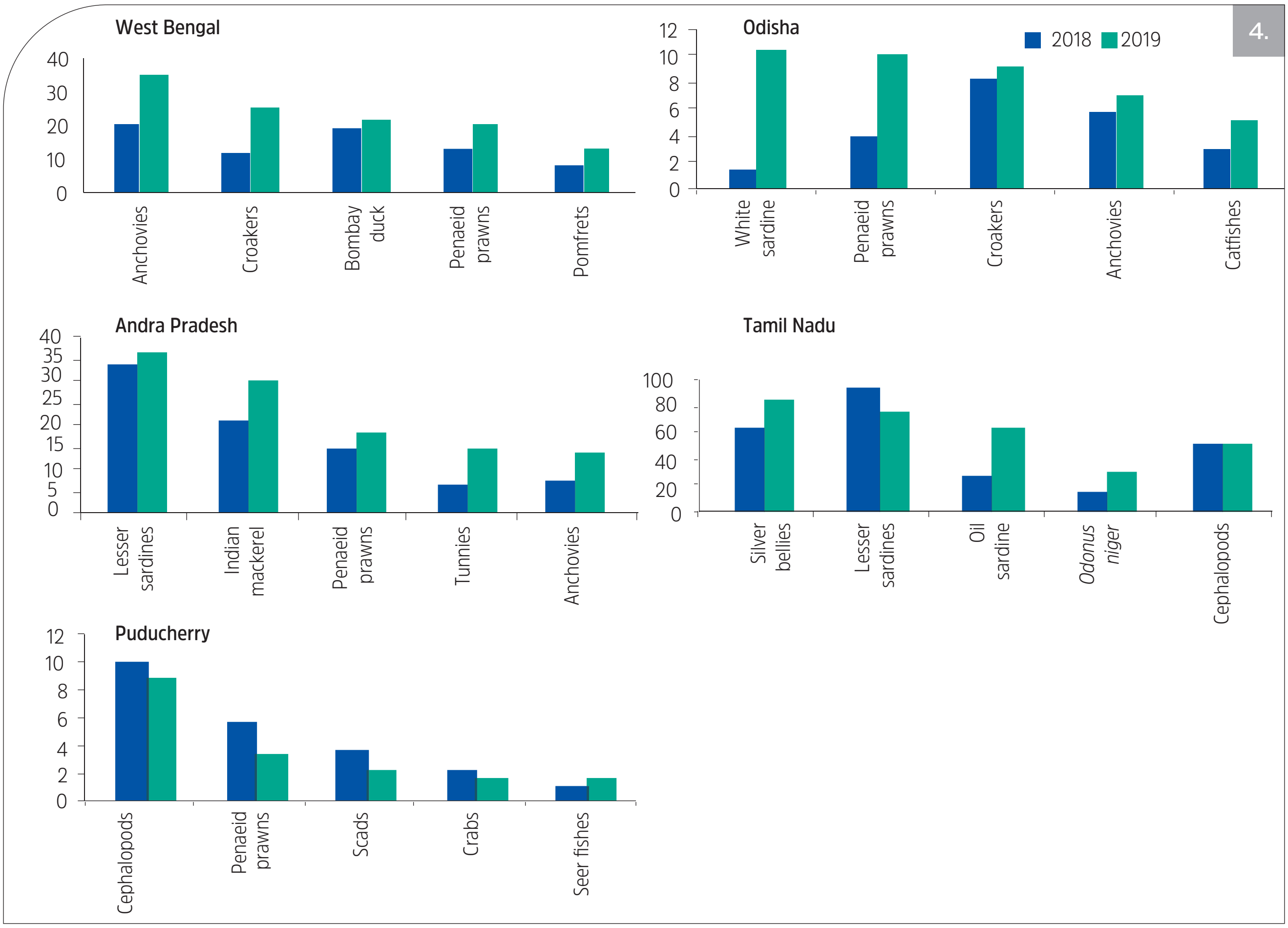
tonnes marine fish landings 48% is pelagic resources, 34% is demersal resources, 12% is crustaceans and 6% is molluscs. The contribution towards total landings by the mechanized sector is 83%, by motorized sector is 16% and by non-mechanized sector is only 1%. The fourth quarter accounted for 34% of landings, first quarter accounted for 27.4%, third quarter accounted for 21.3% and second quarter accounted for 17.3%.

In the northeast coast there is 59% increase in the landings in West Bengal though the Hilsa shad landings continued the declining trend with only 11,307 tonnes landings and 92% of the total landings in the state is by mechanized vessels. In Odisha also Hilsa shad landings declined to 2,207 tonnes and the landings of white sardines increased by six fold to reach 10,571 tonnes. Major loss in the state is in the landings of Indian mackerel by 76% and 60% of the marine fish landings were by multi-day trawl nets.

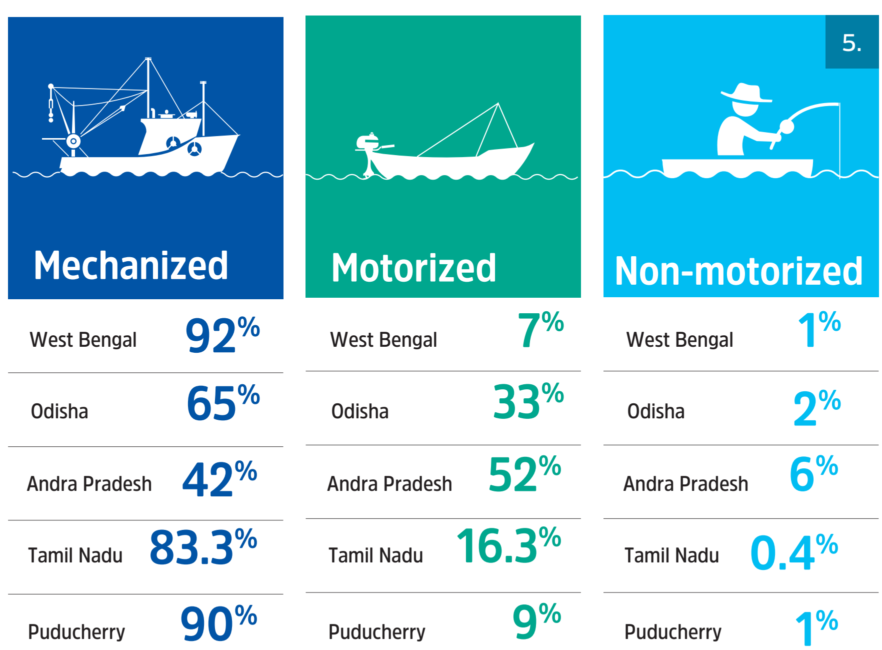
In southeast coast, marine fish landings in Andhra Pradesh increased by 34%, mainly due to increased landings of tuna (116%), anchovies (98%) and Indian mackerel (45%). Contribution from the state to all India marine fish landings increased to 7.2% even though there was a drop in the number of fishing days due to Fani cyclone during the April-May. Tamil Nadu reached the first position with regard to marine fish landings in 2019 with 7,74,571 tonnes contributing 21.8% to all India landings. The mechanized sector accounted for 83.3% of the landings in the state. Marine fish harvest from the union territory of Puducherry decreased to 36,872 tonnes with only 1.0% contribution to the total all India landings. Nearly 90% of the landings in Puducherry was from the mechanized sector.

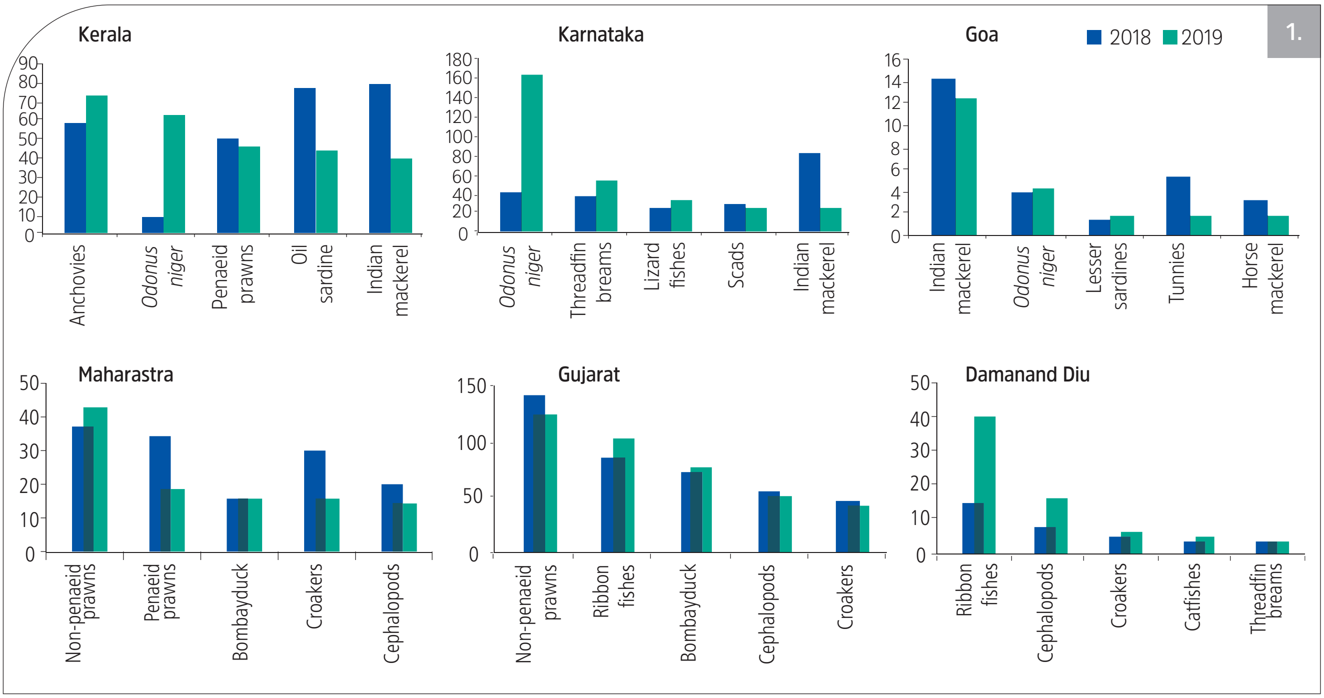
In the southwest coast, the landings in Kerala reduced by 15% to come down to 5,43,836 tonnes with frequent cyclones in Arabian sea forcing reduction in fishing days as a significant reason for the reduction. The major resource, oil sardine landings was only 44,320 tonnes which is the lowest in the last two decades. *Odonus niger*, a low value fish, with 62,782 tonnes emerged as a major component of trawl catch which is mainly used as manure or poultry feed. In Kerala, 78% of the landings is by the mechanized sector. It is very unusual for the west coast to have many cyclonic storms in an year affecting the marine fisheries sector. Cyclonic storms Vayu in June, Hika in September, Kyarr in October and Maha during October-November affected the west coast. Even then marine fish landings in Karnataka increased in 2019 to 5,01,331 tonnes (11%) mainly due to the unusually large landings (1,20,527 tonnes) of red toothed trigger fish (*Odonus niger*) by three fold by the multi-day trawl nets and purseines. Threadfin breams, lizard fishes, scads and Indian mackeral are the other major contributors in Karnataka where 96% of the landings is by the mechanized sector. The state of Goa had a declining trend in 2019 with 32,860 tonnes as the total landings which is 44% less than the landings in 2018. Indian mackerel, *Odonus niger*, lesser sardines, tunnies and horse mackerel were the major species in the state. Landings of oil sardine, *Thryssa* spp., rockcods and tunnies declined in Goa and 94.4% of the landings is by mechanized sector.

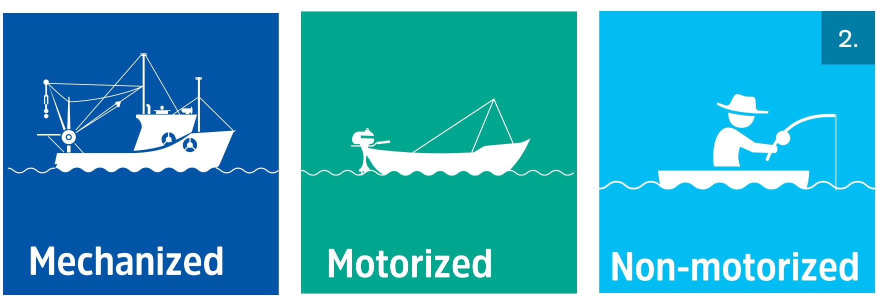
In the northwest coast 32% decrease



1. Assemblage (%): India
2. Sector-wise landings (%): India
3. Quarter-wise landings (%): India
4. Major Landings (in '000 tonnes) in the East Coast
5. Sector-wise landings (%) in the East Coast







State	Mechanized	State	Motorized	State	Non-motorized
Kerala	78%	Kerala	21%	Kerala	1%
Karnataka	96%	Karnataka	3%	Karnataka	1%
Goa	94.4%	Goa	5.1%	Goa	0.5%
Maharashtra	87.4%	Maharashtra	12.4%	Maharashtra	0.2%
Gujarat	88.8%	Gujarat	11.1%	Gujarat	0.1%
Daman & Diu	99.7%	Daman & Diu	0.27%	Daman & Diu	0.03%

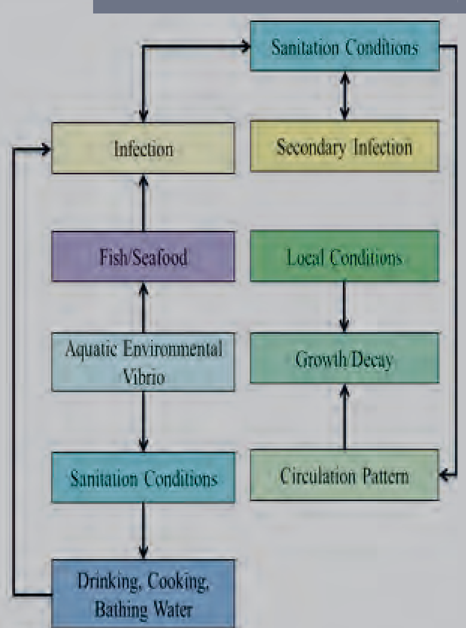
1. Major Landings (in '000 tonnes) in the West Coast
2. Sector-wise landings (%) in the West Coast

was observed in the landings in Maharashtra with only 2,00,979 tonnes landings in 2019. The contribution of mechanized, motorized and artisanal sectors in the state were 87.4%, 12.4% and 0.2% respectively in this year with multi-day trawlers, purse seiners and dolnetters contributing 80% to the total landings in the state. The landings in Gujarat decreased by 4% in 2019 with 7,49,268 tonnes as the landings in the state moving it to the 2nd position and the contribution to national total by the state is 21%. Trawl nets, gillnets, dolnets and hooks & lines are the major gears contributing to the mechanized sector with multi-day trawlers and dolnetters accounting for 71% of the total landings in Gujarat. Landings in the union territory of Daman & Diu in the region in 2019 is 1,11,677 tonnes which is 3.1% of the total national production with multi-day trawlers contributing 90%.

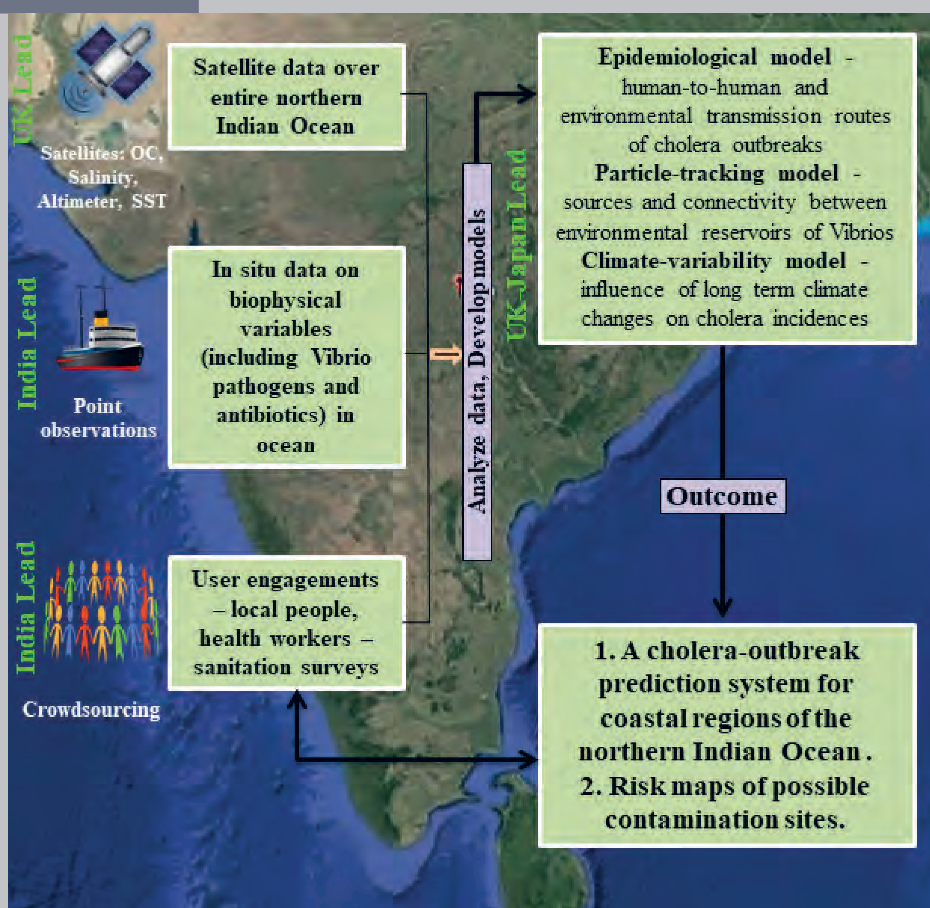
Fisheries and Ecosystem Modelling

Research project: DBT - PODCAST

Pathways of Dispersal for Cholera And Solution Tools (PODCAST)



Pathways of Human Infection by Environmental *Vibrio* Bacteria



With the increase in Cholera outbreaks across the world and the realisation that northern Indian Ocean is a major reservoir of Vibrio cholerae, the project PODCAST was conceived to study the major environmental reservoirs of Vibrios, their connectivity and oceanic transmission routes, link with climate events and the resultant impacts on public health. Three representative coastal locations along the west and east coasts of India were selected for this study

Post monsoon sampling off Kochi revealed that more than the physico-chemical parameters, bio-optical parameters varied with variation in circulation pattern, especially tidal mixing and fresh water influx. Diatoms were the most abundant phytoplankton and copepods were the dominant forms in zooplankton. Faecal contamination was also found to be high in the region.

The aim of the project is to generate maps of Vibrio hotspots and develop a forecast system for cholera outbreaks, in consultation with local populations, health personnel and decision-makers, to help in reducing the risks of waterborne diseases for human health. A sanitation survey has been designed and to understand the sanitation status as well as requirements of coastal population.

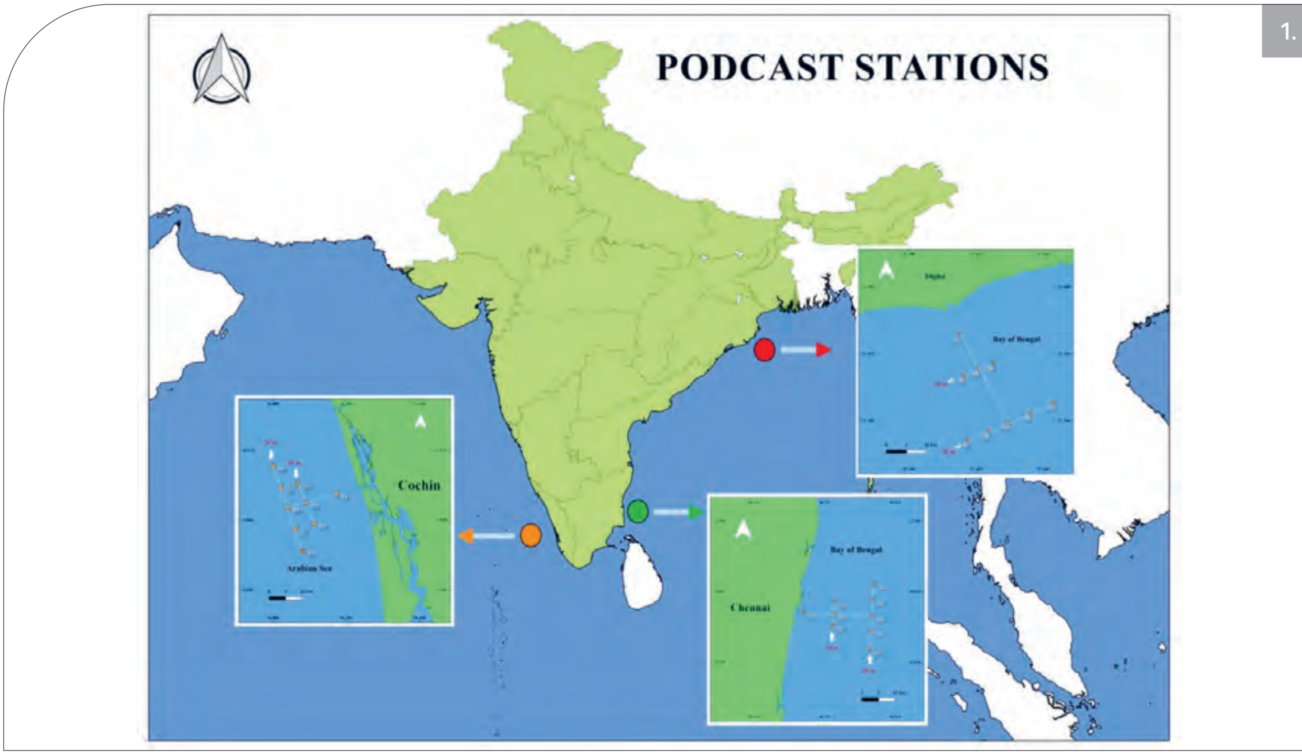
Rehabilitation of Vibrio Infested waters of VembanAd Lake: pollution and solution (REVIVAL)

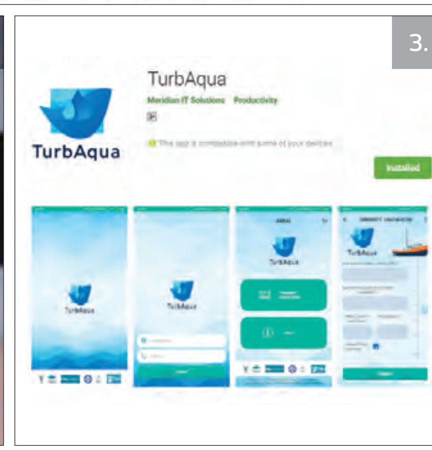
Research project: DST–REVIVAL

The project is based on a novel idea to relate public health with remote sensing. It combines in situ and remote sensing approaches to elucidate the responsible environmental conditions and propose remedial action for microbial contamination in the Vembanad lake, thus enhancing welfare through improving public health. First year of the project was dedicated to taking in situ measurements of water quality–chemical, physical and bio-optical; as well as phytoplankton, zooplankton and benthic abundance and distribution, from 13 representative stations along the Vembanad Lake. A bio-optical laboratory has been set up in CMFRI for this purpose. The hotspots of *Vibrio cholerae* in the lake, the spatio-temporal variations in its prevalence, and its favorable environmental conditions were analysed using the in situ data. Results showed that *Vibrio cholerae* have more affinity towards cyanobacteria when compared to the other groups of phytoplankton and zooplankton and more pathogenic forms occur in the northern parts of the lake compared to the southern part. Data collected are being used for validation of high resolution remote sensed data on chlorophyll and bio-optical parameters generated by Sentinel 2B satellite. A microbial health model for the lake would be developed with validated bio-optical parameters which could lead to the development of a forecast map of the regions susceptible to cholera and in providing advisories to the public. Towards the computational requirements, a high performance computer has been installed at CMFRI with facilities for simulation and modeling named FISH@CMFRI.

To improve the quantity of in situ data available for validation and to widen its domain, citizen science, a novel initiative was started. The aim is to involve public to collect data on the variables required for the project work. For this purpose, a hand-held mini Secchi disc fitted with Forel-Ule colour code designed and fabricated by the UK partner Plymouth Marine Laboratory was used.

The instrument measures the water clarity of the lake. For recording and storage of data, a mobile application





1. Study area of PODCAST project
2. Secchi disc developed as part of REVIVAL project
3. Mobile application named 'TurbAqua' developed by CMFRI

named 'TurbAqua' was developed by CMFRI. A working manual was prepared both in English and Malayalam entitled "Manual for Operation of Mini Secchi Disc and the Mobile App TurbAqua", with an aim to guide the citizen scientists involved. Two citizen science workshops were organised at CMFRI to educate the public on the relevance of water quality in determining environmental and public health. First citizen science workshop conducted on August 5th, 2019 involved around 250 students from 16 colleges around the vicinity of Vembanad Lake.

Second workshop held on December 20, 2019 was meant for stakeholders of Vembanad Lake. Theory and practical training were given to both the groups and the data retrieved on to the CMFRI server from the mobile applications show the enthusiasm with which citizens are participating in the water quality monitoring of the lake.

1.

Carbon dioxide Assimilation off Cochin

Research project: ISRO

The North Western Indian Ocean (NWIO) comprises a unique variety of biogeochemical provinces, including eutrophic, oligotrophic, upwelling, and oxygen-depleted zones, all within an area of relatively small geographic extent. A truly representative location in this ecosystem is the nearshore and coastal waters off Cochin due to its high estuarine discharge, distinct southwest & northeast monsoons, strong upwelling, downwelling and current pattern system. This greatly influences the nutrient pool, phytoplankton distribution pattern and fishery. Further, coastal waters are bio-geochemically active areas, with the magnitude and variability of carbon flux higher than in open ocean environments.

Fixation of inorganic carbon to organic carbon in the ocean is driven purely by phytoplankton. Phytoplankton carbon fixation plays an important role in maintaining the quasi steady state level of atmospheric CO_2. In the light of global warming and the prevalent CO_2 scenario in the regional and global scale, it is inevitable to study the change in CO2 concentration and its spatio-temporal variability.

The project is mainly intended to study the pCO_2 in the estuarine and coastal waters of Cochin as it provides a means of determining net changes in Dissolved Inorganic Carbon (DIC) as a result of photosynthesis and dark respiration, which are directly relevant to biomass production, energy storage and carbon utilization in the ecosystem.

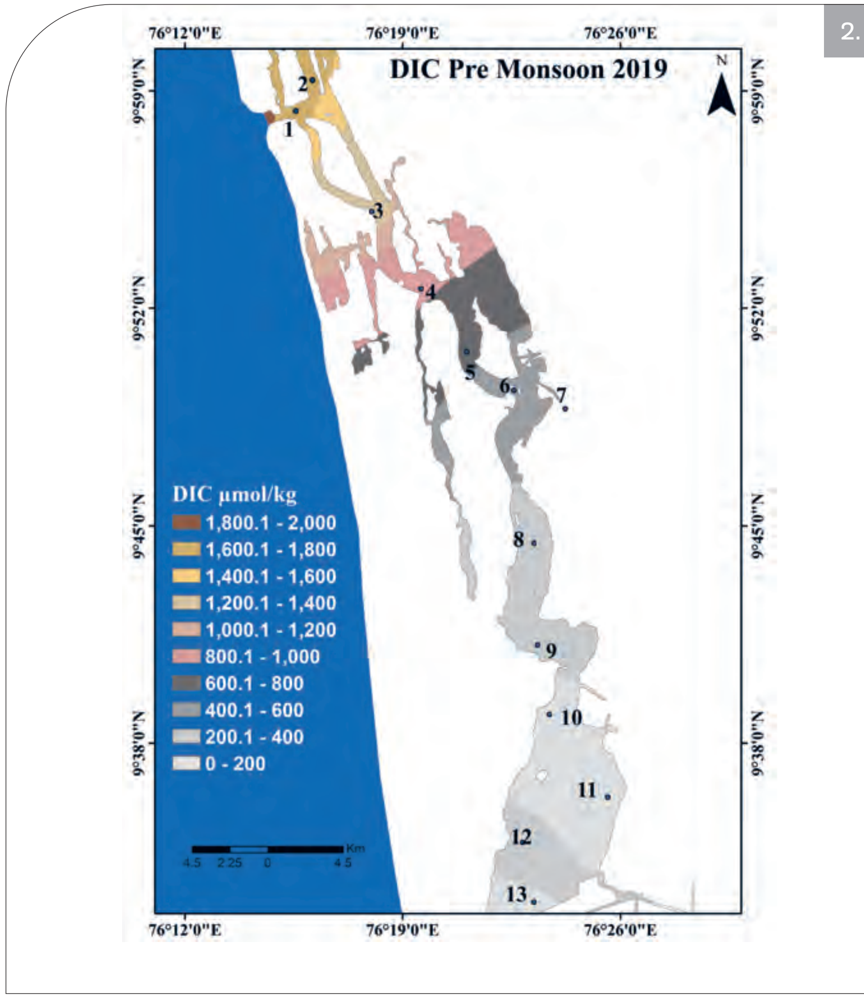
For this, in situ data of carbon dioxide, pH, nutrients, chlorophyll, phytoplankton composition and inherent optical properties in the study area were analysed. Role of aquatic weeds as efficient carbon sinks was evident from the lower DIC concentration in weed infested areas compared to those with uninterrupted water flow. We could also make some inferences regarding the seasonal and inter-annual variations in carbon flux time scales. DIC in the estuary was found to have significant relation with pH, temperature and salinity and highest values were observed during pre-monsoon season. The spatial and temporal pattern of the carbon fluxes and understanding of the fundamental mechanisms that govern this exchange are crucial to predict the future actions of these carbon sinks.

A Model for the Primary Production in Indian Coastal Waters

Research Project: EF/26

Annually, coastal waters of Eastern Arabian Sea (west coast of India) exhibits a bimodal variability in temperature; i.e. during a year, the coast manifests an alternate pattern of warming and cooling phases. It experienced a primary warming during January to May and a primary cooling during May to August. Correspondingly there is a secondary warming through August to October and a secondary cooling through October to December. This might be associated with seasonal oscillation of subsurface water and mixed layer and will have an impact on productivity along the coastal waters of India because it carries nutrient rich subsurface water. Depending on the mode of oscillation, these nutrient rich waters entrained or detrained from the euphotic zone will determine the seasonal productivity. Hence a slab physics NPZD model "EMPOWER" with utility of seasonal oscillation of mixed layer and temperature are used in this study for the understanding of primary productivity. Results of analyses of euphotic zone depth,

1. Citizen science program organized at CMFRI involving college students
2. DIC in study area during pre-monsoon

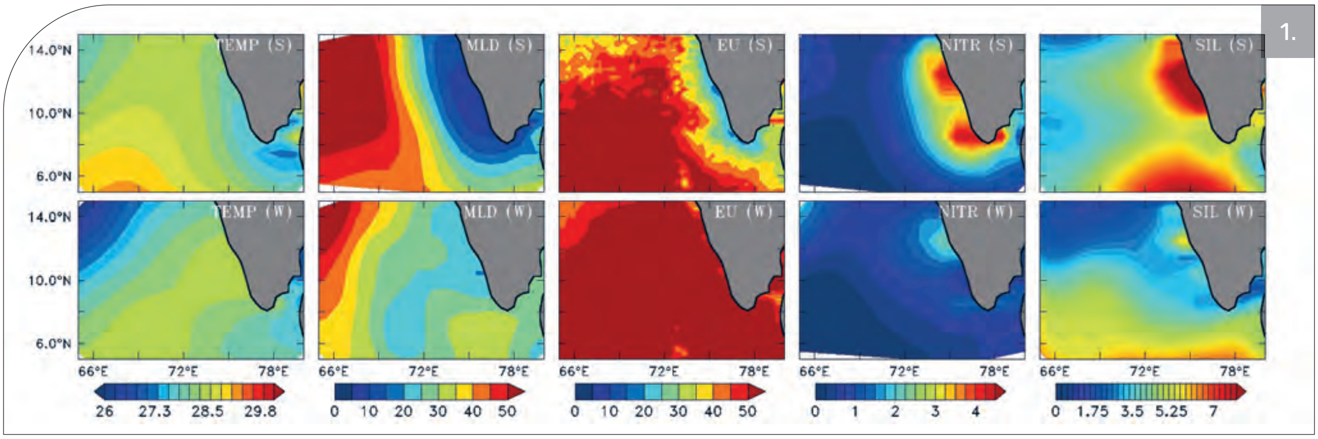


mixed layer depth, temperature and nutrients revealed that nitrates and silicates act as the limiting factors for determining the productivity along the eastern Arabian Sea. Along the south-west coast of India, even though the mixed layer was limited to the vicinity of euphotic zone during both summer and winter monsoon season, the coast manifested enhanced productivity only during the summer monsoon. This was due to the entrainment of nitrates into the mixed layer due to the upwelling during the summer monsoon. During the winter monsoon the coast was characterized by downwelling and nitrates were detrained from the mixed layer.

Productivity vs. Upwelling vs. Precipitation

The South Eastern Arabian Sea (SEAS) is an upwelling dominated region, where the seasonally reversing winds and currents are the major physical forces driving primary production. During the summer monsoon, nutrient rich riverine water is excessively discharged into coastal waters. The heavy inflow of turbid nutrient rich water into coastal region during summer monsoon would facilitate primary production resulting in the enhancement of phytoplankton biomass. In the present study, we investigated the relative roles

1.



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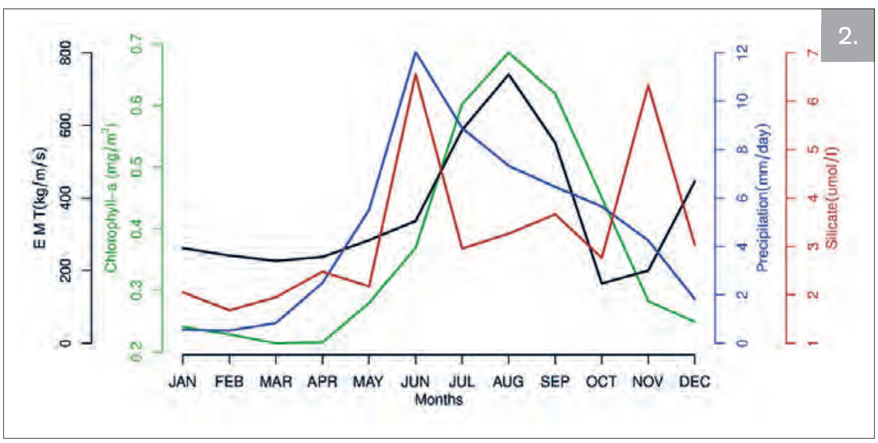

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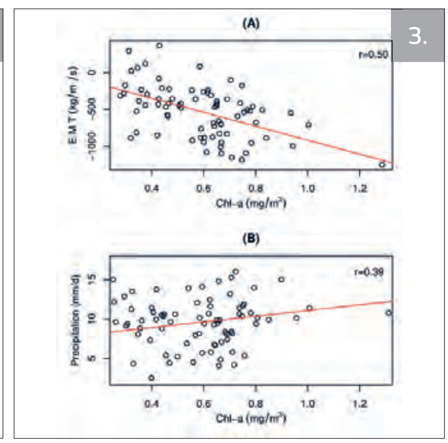


1. Climatology of SST, mixed layer depth (m), euphotic zone (m), nitrates (micro mole) and silicates (micro mole) along the south-west coast of India during the summer (upper panel) and winter (lower panel) monsoon
2. Area averaged monthly climatology time series of Chl-a, EMT, Precipitation and Silicate
3. Scatter plot between Chl-a and (A) EMT (B) Precipitation

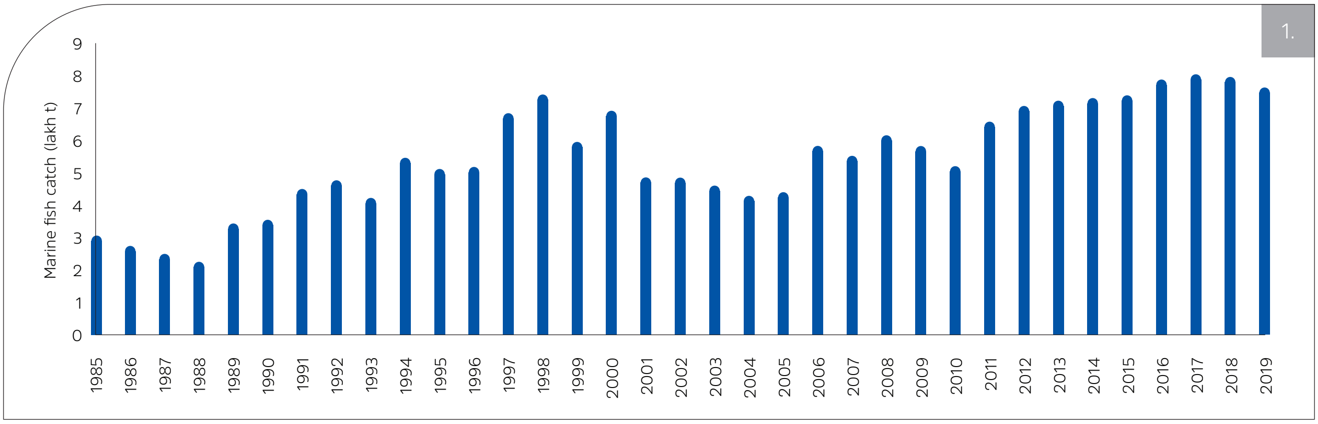
of upwelling and precipitation that drive productivity along the south-west coast of India.

The available remote sensing data sets for chlorophyll-a (Chl-a), precipitation, silicates and sea surface winds were used for the period 1998 to 2016. Ekman Mass Transport (EMT) derived from the meridional component of winds was used as upwelling index. The overall climatology analysis in the SEAS reveals that the enhancement of Chl-a along the south-west coast of India occurred during summer monsoon season and it is perfectly overlapping with strong upwelling (EMT), heavy precipitation and nutrient discharge (Silicate) during summer monsoon. We observed a significant correlation between coastal upwelling index and precipitation with Chl-a in SEAS. The linear step-wise regression analysis showed that the correlations of Chl-a with EMT (r=0.5) were higher than that of precipitation (r=0.39). The relationship is showed in the fitted line. Further, during the study period, we witnessed an interesting result in some specific years (during 2003 and 2012): when EMT anomaly is positive and precipitation anomaly is negative, we could observe that the coastal productivity is nominal. During those specific years, there was no augmentation of Chl-a even when the Ekman transport is very strong. We conclude that apart from upwelling, high precipitation during summer monsoon also contributes to coastal productivity along SEAS significantly. The study also proposes scope for a detailed analysis of those specific years with the help of sufficient in-situ data especially for the riverine discharge.

Gujarat

Research Project DEM/RMS/09

Large pelagic fishes landed in Veraval fish landing center

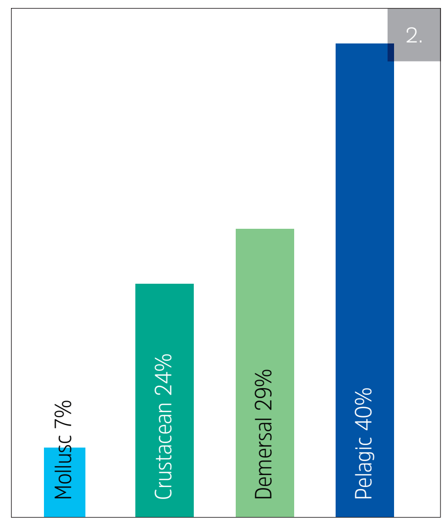


The annual marine fish landings of Gujarat for the year 2019 is estimated at 7.49 lakh t, with a decline of 4% compared to 2018 fish landings. Maximum catch and catch rates (CPUE) was noticed during post-monsoon and winter season, which are the peak fishing seasons along the Gujarat coast. Catch and fishing effort were very less during the post-summer and monsoon seasons because of low productivity, fishing ban and rough weather. Gir-Somnath District was the highest contributor (3.31 lakh t) to the total fish landings of Gujarat.

In realm wise contribution, pelagic finfish resources contributed nearly 40% of the total marine fish landings of Gujarat for the year 2019, followed by demersal 29%, crustaceans 24% and molluscan resources (7%). The quantum of share by crustacean resources is mainly because of non-penaeid shrimp, followed by penaeid shrimp and crabs. Squids mainly contributed to molluscan landings, followed by cuttlefish and small quantities of octopus. Non-penaeid shrimp contributed maximum (1.23 lakh t–16% to the total catch) among all the resources, followed by ribbonfishes (1.03 lakh t), bombayduck (0.75 lakh t), croakers (0.43 lakh t), penaeid shrimp (0.36 lakh t), catfishes (0.34 lakh t), threadfin breams (0.29 lakh t), squids (0.25 lakh t), cuttlefish (0.25 lakh t), other perches (0.19 lakh t), soles (0.14 lakh t) and lizardfishes (0.12 lakh t).

District-wise Gir-Somnath ranked first with 3.31 lakh t, followed by Dev Bhoomi Dwaraka (1.26 lakh t), Amreli (0.87 lakh t), Porbandar (0.78 lakh t), Junagadh (0.69 lakh t), Kutch (0.42 lakh t), Valsad (6675 lakh t), Navsari (5718 t), Jamnagar (2875 t), Morbi (218 t) and Bharuch (7 t).

Sector-wise, fishery landings of Gujarat showed dominance of mechanized fishing vessels with a catch of 6.65 lakh t, followed by motorized vessels 0.83 lakh t and non-motorized vessels contributing meagerly of 689 t. Catch from mechanized vessels was mainly from multiday trawlers (MDTN), followed by mechanized dollnetters (MDOL) and mechanized gillnetters (MGN). Highest catch rates were observed in MDTN (4.50 t/unit), followed by MDOL (2.40 t/unit), MGN (1.10 t/unit), MTN (1.0 t/unit), etc. Catch per unit effort (kg/h) was maximum for the MTN (145 kg/h), followed by MDOL (100 kg/h), MDTN (37 kg/h), OBDOL (36 kg/h) MGN (14 kg/h) and OBGN (9 kg/h).



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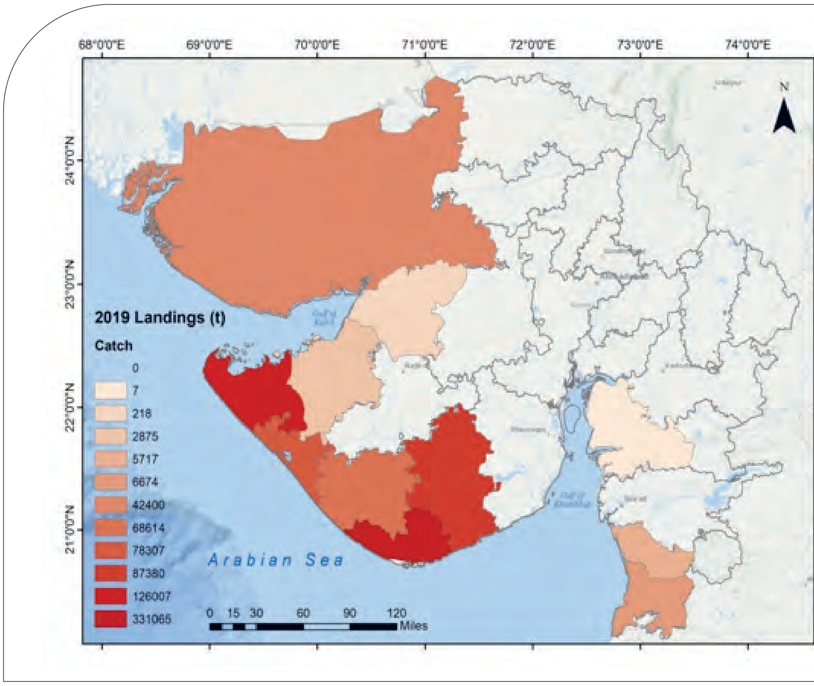

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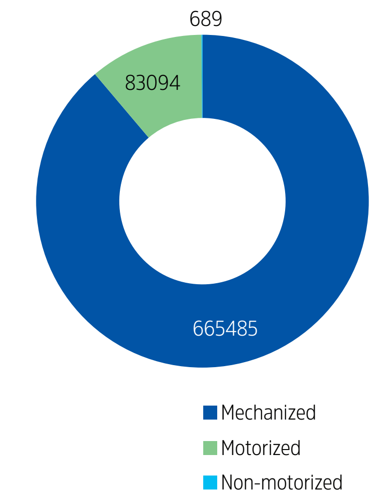


1. Time series marine fish landings (lakh t) of Gujarat
2. Category wise marine fish catch of Gujarat in 2019
3. District wise marine fish catch
4. Marine fish catch (t) contributed by different sub-sectors in Gujarat (2019)

Pelagic Resources

Pelagic fishes recorded 2.78 lakh t in 2019 (40%) to the total marine fish landings of Gujarat. Ribbonfishes dominated, followed by bombayduck, clupeids, carangids, tunas, Indian mackerel, seerfishes, etc. The estimated catch of ribbonfish was 1.03 lakh t, an increase of 18% over the previous year. Ribbonfish formed about 13.7% of total and 36.4% of pelagic fish landings. Mechanized multi-day trawlers alone contributed 72% of ribbonfish landings. Bombayduck landing was 75032 t, accounting 10% of the total and 26.5% of the pelagic landings. Mechanized dolnet was the major gear contributing nearly 88% of bombayduck landings. Carangids formed major fishery in Gujarat with landings of 20,125 t and *Megalaspis cordyla* was the species (36%). Tunas formed about 4% of pelagic fish landings of Gujarat with a production of 10,438 t, 28% decline in catches were recorded compared to 2018. *Euthynnus affinis* (38%), *Thunnus albaracres* (31%) and *T tonggol* (22%) were the three main species dominant in the tuna fishery. Clupeids (43,383 t) also contributed significantly (15.4%) to the pelagic resources and 5.8% of total landings. *Coilia dussumeri* (36%) being the main species in the fishery. Indian mackerel (7,595 t) and seerfishes (7,461 t) were the other important pelagic resources contributing to the fish landings of Gujarat.

Demersal resources

Demersal fish landings were 201044 t, a decline of 8.64% from the previous year. Maximum catch was contributed by multi-day trawlers (69.35%), followed by multi-day dolnetters (11.16%), outboard gillnetters (9.05%) and multi-day gillnetters (7.31%). Croakers were the most dominant group (21.42%, 43054 t) to the demersal landings. Croakers were predominately caught in

Biological parameters of commercially important pelagic fishes of Gujarat

Species	Length range (mm)	Mean length (mm)	Sex ratio (M:F)	Mature%	Average fecundity (No's)	Ova diameter (µm)
Rastrelliger. kanagurta	212-277	237.11	2	38.46	47,876	296-635
Harpadon nehereus	147-280	203.39	0.84	37.28	82,758	487-777
Coilia dussumieri	94-183	146.4	1.05	30.35	4,587	170-315
Megalaspis cordyla	278-455	381.98	2.21	65.16	1,00,293	169-780
Trichiurus lepturus	425-1038	666.8	1.7	53.50	1,33,731	538-1813
Scomberomorus guttatus	315-820	410.41	0.72	8.62	1,22,354	563-942
Thunnus tonggol	550-665	625.33	0.4	30.76	3,22,857	167-225
Euthynnus affinis	327-780	466.54	0.64	59.52	89,425	194-520
Coryphaena hippurus	580-1073	809.19	3.1	95.83	1,81,998	182-1712
Chirocentrus dorab	365-674	526.91	1.84	66.66	34,453	99-1310
Rachycentron canadum	333-1030	608.02	0.52	59.09	3,88,257	214-1,153
Aluterus monoceros	177-608	441.96	1.56	50.25	1,67,849	119-358
Lepturacanthus savala	322-645	zzz524.2	1.78	62.4	12,478	-
Eupleurogrammus muticus	390-736	618.190	1.24	52.34	4,587	-
Thunnus albacares	560-1900	860.63	-	-	-	-
Katsuwonus pelamis	400-710	532.6	-	-	-	-
Scomberomorus commerson	390-960	690.90	-	-	-	-

multi-day trawlers (51.25%) followed by mechanized dolnetters (23.08%) and outboard gillnetters (17.94%). The 4th quarter (Oct-Dec) was the most productive phase for the croaker fishery accounting for 33.35% annual landings. The 1st quarter with a contribution of 32.29%. Other major contributors included catfishes (16.69%), threadfin breams (14.27%), other perches (9.43%) and soles (6.94%). October to December (4th quarter) was the most productive period for the fishery, (34.11%)followed by 1st quarter (32.63%). Major drop in catches were observed for rock cods (-54.09%), halibut (-42.15%), other perches (-34.28%), threadfin breams (-22.71%), and sharks (-17.18%) compared to previous year. Increase in landings were goat fishes (+120.85%), silver pomfrets (+47.96%), catfishes (+34.44%) and eels (+32.21%). Both guitarfishes and rays recorded an increase in landings by 28.85 and 26.36% respectively.

Crustacean resources

Crustacean resources formed nearly 24% (1.69 lakh t) of total fish landings of Gujarat during 2019 with a decline of 8.92% compared to previous year. Non-penaeid shrimp were the major component (72.39%) in the crustacean landings followed by penaeid shrimp (21.17%), crabs (4.42%), stomatopods (1.64%) and lobsters (0.3%). The prominent gears contributing to the crustacean landings were dolnets (69.03%) and trawlers (19.1%). Non-penaeids accounted for 3/4th of the crustacean landings and recorded a decrease of 13.15% compared to 2018. They were mainly exploited by dolnetters (85.31%) followed by mechanized trawlers (10.62%). Penaeid shrimp landing was 35936 t which is marginally higher (+6.5%) than 2018.

1. Barracuda landed by Mechanized gillnetters in Bhidia fishing harbor
2. Apogonid landings by MDTN in Veraval harbor
3. Catfish catches landed by Multi-day trawlers in Mangrol harbor

Population and mortality parameters of commercially important pelagic resources of Gujarat

Species	L_∞ (mm)	K (yr^{-1})	M (yr^{-1})	F (yr^{-1})	Z (yr^{-1})	E
Rastrelliger kanagurta	318	0.84	1.72	2.1	3.82	0.55
Harpadon nehereus	355	0.91	0.77	3.88	4.65	0.83
Coilia dussumieri	234	1.25	1.89	5.44	7.33	0.74
Megalaspis cordyla	483	0.86	0.92	3.18	4.1	0.78
Trichiurus lepturus	1315	0.33	0.51	0.96	1.47	0.65
Scomberomorus guttatus	805	0.86	1.16	3.21	4.37	0.73
Thunnus tonggol	930	0.34	0.65	0.69	1.34	0.51
Euthynnus affinis	821	0.63	0.78	1.5	2.28	0.65
Coryphaena hippurus	1506	0.38	0.34	0.78	1.12	0.69

Reproductive parameters of selected demersal species landed in Gujarat

Species	L_{min} (mm)	Lm_{50} (mm)	Peak recruitment	Peak spawning season	Av. Fecundity
Epinephelus diacanthus	18.9	265	Mar-May	Sep-Nov	76512
Nemipterus japonicus	14	203	Aug-Nov	Oct-Nov	82760
Priacanthus hamrur	15.9	206	Jul-Oct	Sep-Oct	67346
Johnius glaucus	12.9	194	Jul-Sep	Sep-Nov	33323
Otolithes cuvieri	15.3	248	Jul-Sep	Oct-Dec	78286
Saurida tumbil	21.9	294	May-Aug	Nov-Dec	93735
Pampus argenteus	10.7	173	Sep-Nov	Nov-Jan	43020
Parastromatus niger	20.8	322	Jul-Oct	Oct-Dec	68680

Growth, mortality and exploitation parameters of selected demersal species landed in Gujarat

Species	Length range (mm)	L_∞ (mm)	K (yr^{-1})	Z (yr^{-1})	M (yr^{-1})	F (yr^{-1})	LC_{50} (mm)	E
Epinephelus diacanthus	82-485	575	0.64	2.91	1.11	1.8	14.6	0.62
Nemipterus japonicus	78-333	361	0.9	3.31	1.58	1.73	11.5	0.52
Priacanthus hamrur	115-408	454	0.65	3.11	1.2	1.91	18.2	0.61
Johnius glaucus	88-324	345	0.36	2.1	0.88	1.22	18.1	0.58
Otolithes cuvieri	141-367	391	0.79	3.31	1.42	1.89	22.2	0.57
Saurida tumbil	136-515	604	0.64	2.31	1.1	1.21	24.1	0.52
Pampus argenteus	59-271	291	0.51	2.3	1.16	1.14	11.1	0.5
Parastromatus niger	88-521	584	0.55	2.71	1	1.71	19.1	0.63

Growth, mortality and exploitation pattern of selected crustaceans landed along Gujarat

Species	L_∞ (mm)	K (yr^{-1})	Z (yr^{-1})	M (yr^{-1})	E
Penaeus monodon (M)	377	1.09	4.29	1.79	0.58
P. monodon (F)	384	1.02	4.1	1.67	0.59
P. semisulcatus (M)	255.7	1.45	5.95	2.38	0.6
P. semisulcatus (F)	265.2	1.38	5.85	2.26	0.61
Metapenaeus affinis (M)	190.5	1.62	6.66	2.66	0.6
M. affinis (F)	212.8	1.51	6.35	2.48	0.61
M. monoceros (M)	251.5	1.47	5.87	2.41	0.59
M. monoceros (F)	271.5	1.4	5.33	2.3	0.57
Solenocera crassicornis (M)	126.3	1.35	4.41	2.21	0.50
S. crassicornis (F)	147.5	1.28	4.84	2.1	0.57
Parapenaeopsis stylifera (M)	160	1.9	6.65	3.12	0.53
P. stylifera (F)	175.4	1.7	6.58	2.79	0.58
Portunus sanguinolentus (M) [CW]	161	1.5	4.99	2.46	0.51
P. sanguinolentus (F) [CW]	167	1.48	5.21	2.43	0.53
Panulirus polyphagus (Pooled)	369.5	0.35	1.48	0.57	0.61

M - Male; F - Female; CW - Claw width

Fecundity of the major shrimp species landed along the Gujarat coast

Species	Lm_{50} (mm)	Length range (TL) (mm)	Fecundity range
Metapenaeus affinis	110.8	104-240	45576-595054
Metapenaeus monoceros	127.6	102-217	34414-535655
Penaeus monodon	155.5	132-372	31877-1048887
Penaeus semisulcatus	129.1	112-240	43704-879718
Solenocera crassicornis	77.7	61-130	21584-154614
Parapenaeopsis stylifera	89.6	84-139	40429-270157

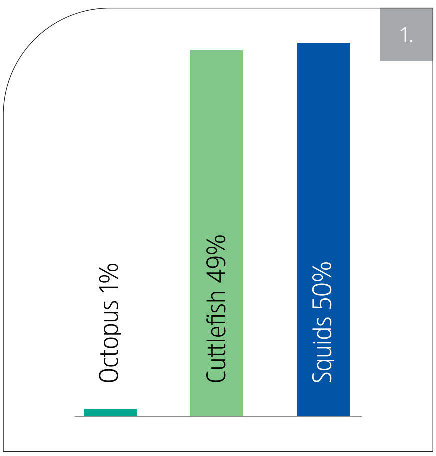
Among penaeid shrimp, *Parapenaeopsis stylifera* was the most dominant species. Crab landings were 7501 t which is 2.9% lower than 2018. Trawls accounted for almost 67% of the total crab landings. Other gears with significant contribution were mechanized dolnets (12.14%), outboard gillnets (16.11%). Lobsters with a landing of 639 t accounted for nearly 0.3% of total crustacean landings. There was a decline of 27.44% in lobster landings. Lobsters were mainly exploited by outboard gillnetters (49.57%) followed by multi-day trawlers (32.89%). Stomatopod landing was 2789 t, 10% higher than 2017. Maximum landings was from multi-day trawlers (45.7%) followed by mechanized dolnets (38.84%) and single day trawlers (15.44%). Jan-Mar (1st quarter) contributed 37.83, 28.09%, 21.24, 30.20 and 32.77% of crabs, lobsters, non-penaeid shrimp, penaeid shrimp and stomatopds landing, respectively. The respective contribution during the period of Oct-Dec (4th quarter) were 22.15, 19.46, 45.50, 37.06 and 47.58%.

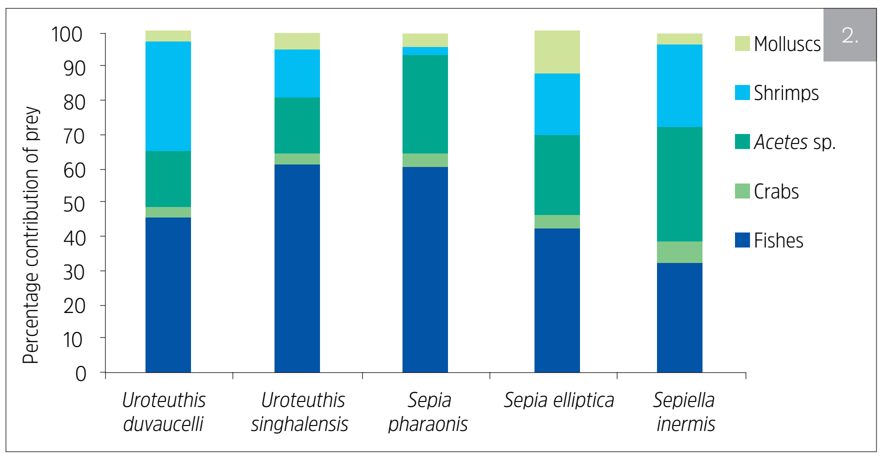
Molluscan resources

Cephalopods were the major molluscan resource landed in Gujarat (49988 t) in 2019 which formed 7.0% of the total fish landings. Major groups in the cephalopod landings were squids (50%) followed by cuttlefishes (49%) and octopus (1%). Cuttlefish fishery was dominated by *Sepia elliptica* and *Sepia pharonis, Sepiella inermis, Sepia prasadi, Sepia omani, Sepia kobiensis* etc. formed marginal landings. But in case of squid *Uroteuthes (P.) duvauceli* contributed 74% and other squids including *Uroteuthes (P.) singhalensis* contributed 26% the total squid landings.

MDTN contributed maximum cephalopod catch of 90.78%, followed by MOTHS (5.55%), MTN (1.47%), OBGN (1.44%) and MDOL (0.72%). Species-wise the cephalopods showed the dominance of Indian Squid, *U.(P.) duvauceli* followed by both *S. pharonis, S. elliptica, U. (P.) singhalensis* and octopus. Diet composition of squids and cuttlefishes was analyzed to understand the prey preference across different resources. Fishes (53.47%) formed the major diet in the guts of squid, followed by shrimps (23.29%), *Acetes* (16.23%), molluscs (3.88%) and crabs (3.29%). Major diet item found in the guts of cuttlefishes was fishes (48%), followed by *Acetes* (35%), shrimps (12%), crabs (4%) and molluscs (1%).

1. Group wise cephalopod landings of Gujarat in 2019
2. Diet composition of commercially important cephalopod resources of Gujarat





Month wise cephalopod landings (t) of Gujarat in the year 2019

Resources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Squids	2646	1982	3976	3540	1484	72	0	410	2136	2839	1686	4225	24995
Cuttlefish	2100	1439	1424	1358	784	26	0	425	3112	4476	4584	4959	24687
Octopus	45	31	60	60	11	0	0	0	56	24	14	6	307
TOTAL													49988

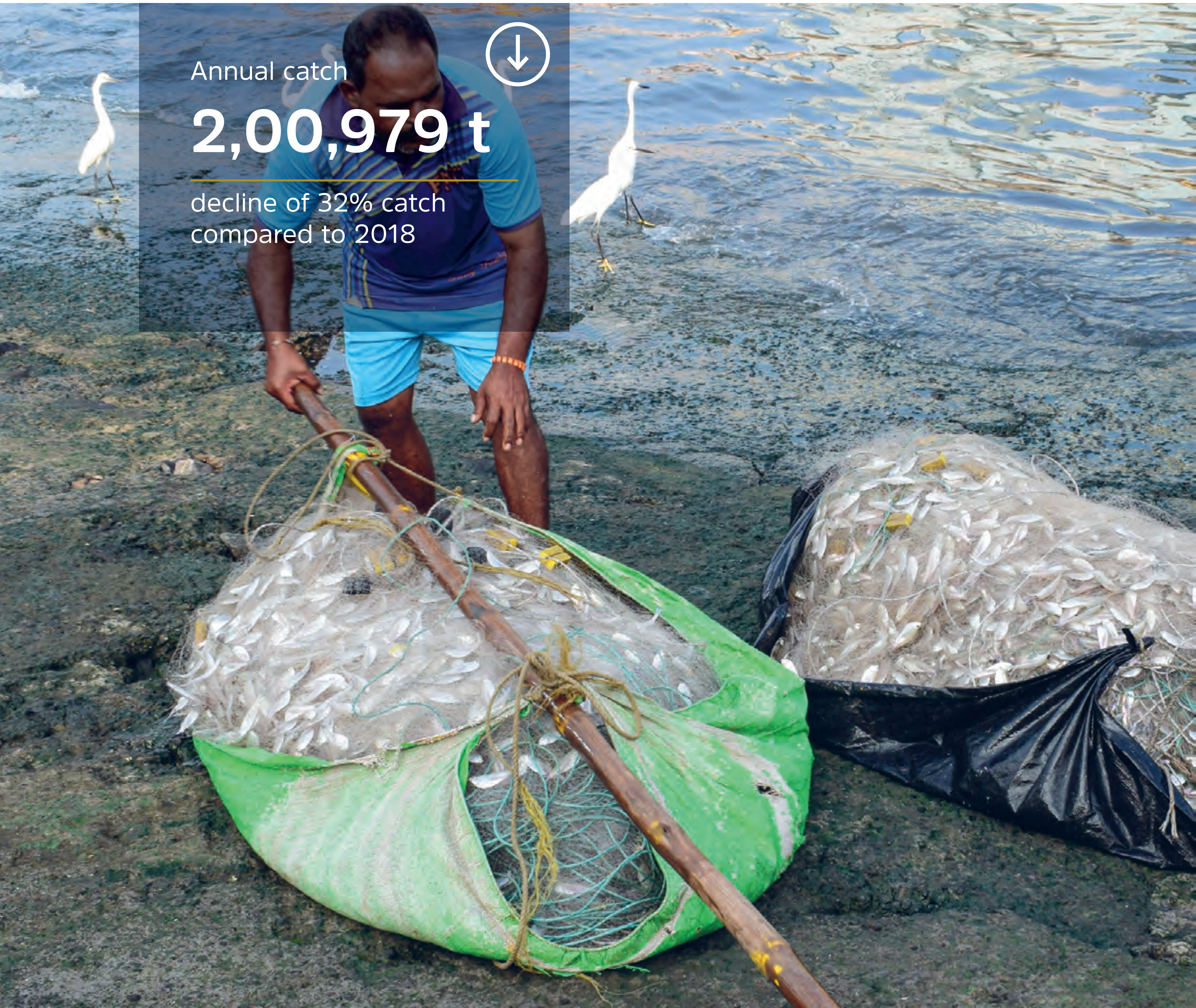
Table 8 Biological characteristics of commercially important cephalopod resources of Gujarat

Species	Min. Length (mm)	Max. Length (mm)	Mean length (mm)	Lr (mm)	Lc_{50} (mm)	Lm_{50} (mm)	K (yr^{-1})	Sex Ratio (M:F)	Mature specimen %	a	b	R^2
U (P) duvaucelii	36	281	113.1	34.00	115.0	112	0.85	1:0.65	64.2	0.0004	2.52	0.92
U (P) singhalensis	52	318	122.0	52.50	124.5	117	0.90	1:0.73	65.3	0.0090	2.08	0.80
S. pharonis	63	323	175.2	64.20	178. 0	171	1.14	1:0.38	54.4	0.0032	2.86	0.91
S. elliptica	45	214	101.5	46.00	1046.5	101	0.94	1:0.72	64.9	0.0510	1.68	0.77
S. inermis	21	94	60.5	21.50	61.5	58	0.93	1:0.73	71.5	0.0028	2.41	0.76

Maharashtra

Research Project: CFD/RMS/13

Nearshore gillnet catch of white sardine

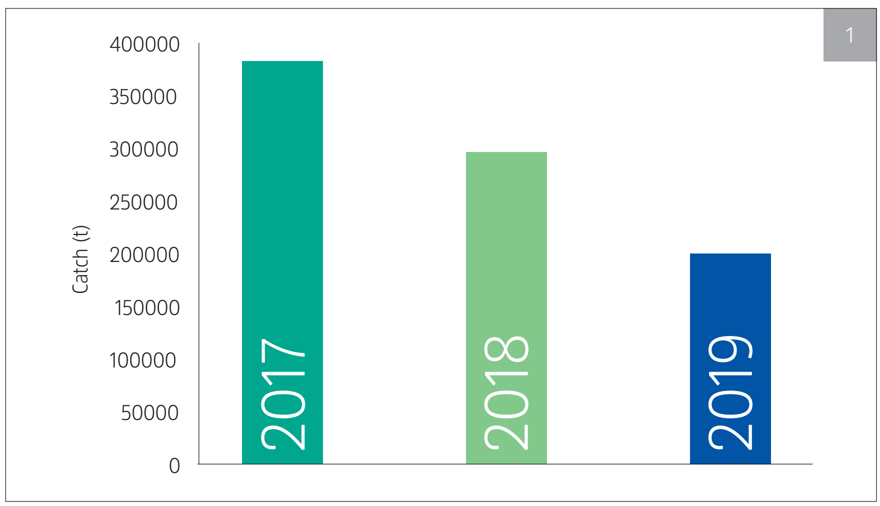


Annual catch

2,00,979 t

decline of 32% catch compared to 2018

1. Fish landing trend in the preceding three years in Maharashtra
2. Top 10 groups of marine fishery resources and their percent share to Maharashtra landings



The estimated marine fish landings of Maharashtra in 2019 was 200979 t, which formed 5.6% of all India marine fish landings. The landings decreased by 32% from the previous year. The catch decreased compared to last few years ie, 2017 (381142 t), to 2019 (200979 t). Pelagic resources accounted for 39%, crustacean 31% demersal 22% and mollusc 7%.

Major resources caught were non-penaeid shrimp (21%), penaeid shrimp (9%), bombayduck and croakers (8.2%), Indian mackerel (6.9%), threadfin breams (5.9%), squids (5.1%), ribbonfishes (4%), golden anchovy (4%), horse mackerel (3.5%), cuttlefish (2.1%), Silver pomfret (2.0%). Trawl accounted for 55%, set bagnet (SBN/Dolnet) 23%, purse seines (15%), and gillnet (7%). Estimated value of marine fish landings of Maharashtra during the year 2019 at the first point of sale was ₹6402 crores.

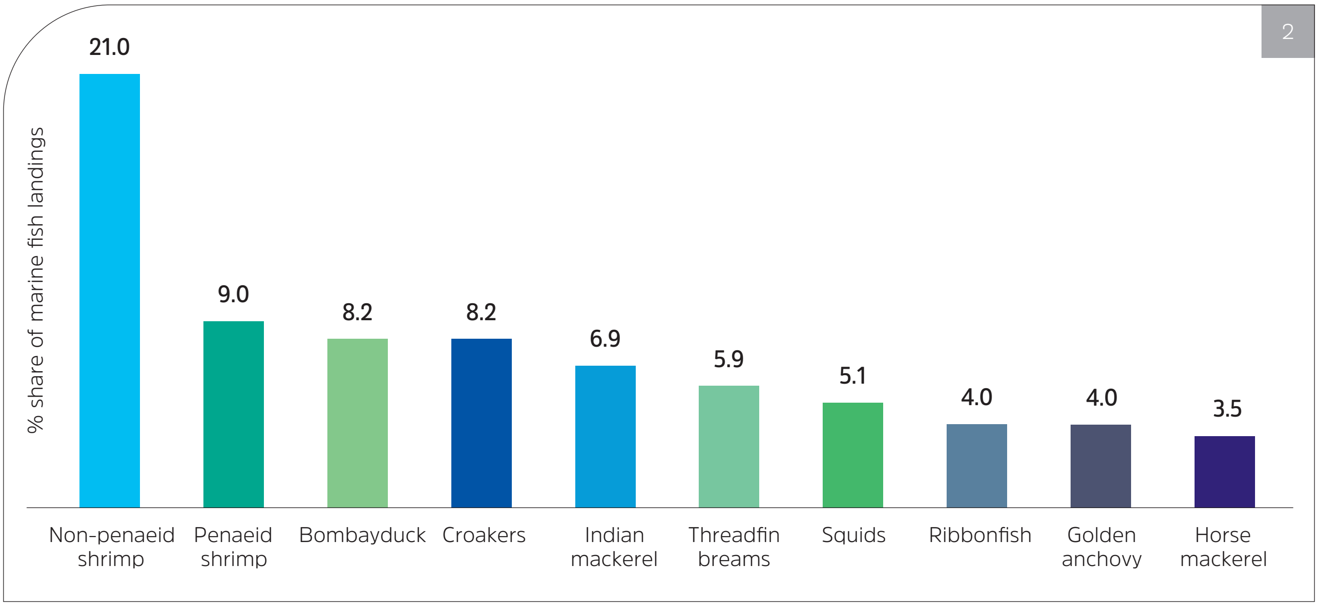
Pelagic resources

Pelagic fishery contributed 39% to the total marine catch in Maharashtra. Catch decreased from 1,11,244 t (2018) to 78,983 t due to decrease in landings of Indian mackerel, ribbonfish, and horse mackerel. Major gear were purse seiners (36%), trawler (25%), bagnet (25%), gillnets (14%) and others (0.2%). Bombayduck formed 22% of the pelagic fish landings of which 76% was from bagnet followed by trawl (23%). Indian mackerel (18%), carangids (10%), ribbonfish (11%), golden anchovy (11%), horse mackerel (9%), tuna (8%), seerfish (5%) and wolf herring (2%).

Major species

Bombayduck: With 16,435 t bombayduck contributed 8.2% of total Maharashtra fishery and was the dominant species amongst the pelagic resources. Almost 76% of the bombayduck landing in Maharashtra was by SBN followed by trawl net 23%. Size range in the fishery was 88 to 300 mm TL and the recorded mode was 181-195 mm. Sex ratio was observed to be 1:1.8. Main diet components were *N. tenuipes* and *Acetes* spp fishes including *C. dussumieri*, *H. nehereus*.

Indian mackerel: With an estimated catch of 13,822 t mackerel formed nearly 7% of the total fish catch. Compared to last year Indian mackerel decreased by 52.5%. 77% of the catch was contributed by purse seine and the remaining 13% by trawlers and 10% by gillnetter. The size range in the



commercial fishery was 108-296 mm. Mean size was 222 mm with mode 201- 205 mm. Sex ratio observed was 1:0.6. Females were mature and gravid from January to March. Gut content analysis showed dominance of amphipod, copepod, *Coscinodiscus* spp., Foraminifera and *Acetes* sp.

Golden anchovy: contributed 4% (8,102 t) to the total marine fish landings recording a decrease of 14% (2018). Bagnet landings contributed 58% while trawl nets contributed 36% of the total catch. Gillnet contributed 6%. Mean size was 150 mm with mode 141-145 mm. The sex ratio was observed to be 1:1.2. Gravid and mature specimens were seen from October to February. Major food items comprised copepods, *Acetes* spp., crustaceans and Amphipods.

Ribbonfish: contributed about 4% (8,123 t) to the total fish catch of Maharashtra. Catch decreased by 85% compared to previous year. Trawl net contributed the major catch (72%) of this resource followed by bagnet net (17%), purse seine (7%) and gillnet (4%). *Trichiurus lepturus* ranged in size from 340-1120 mm with a mean size of 735 mm. Sex ratio was observed to be 1:3.5. Females were in the mature and gravid condition during August-January. Gut content analysis showed the presence of fish, *Acetes* spp, *Loligo* spp. and ribbonfish.

Tuna: contributed 3.1% (6,246 t) of the total catch of Maharashtra. The resource was represented by seven species in Maharashtra; five neritic and two oceanic species *E. affinis, A. thazard, A. rochei, T. tonggol* and *S. orientalis* represented the neritic species. Oceanic species were *T. albacares* and *K. pelamis*. Major gear contributing to tuna fishery was purse seine 80% (4,996 t) followed by the gillnet 15% (954 t) and trawler 5% (287 t). The size range was 310-782 mm for *E affinis* and 235-580 mm for *A. thazard*. Mature fishes were observed during April and September for both species. Major food component observed were fish, shrimp, acetes, crab and cepahlopods in *E. affinis* while in *A. thazard* fish and *Acetes* spp. were major food component.

Seerfish: contributed 4,054 t (2%) to the total catch in which *S. commerson* (56%) and *S. guttatus* (44%) were the only two species in the fishery. About 47% of *S. guttatus* was from gillnets followed by purse seine (27%), trawl net (21%), and bagnet (4%). *S. guttatus* ranged from 142-965 mm, mean size was 412 mm. Sex ratio was 1:0.82, mature and gravid specimens observed during October to December. Gut content showed fish and *Acetes* spp. as major food components.

Barracuda: contributed 348 t to the total catch. About (70%) of the barracuda was contributed by purse

1. Shrimp Landing at New Ferry Wharf

seines followed by trawlers (16%) and gillnet (14%). *Sphyraena putnamae* ranged between 333-1020 mm Females in mature and gravid stages were noticed during August to September. Gut content analysis showed squid and fish as the major food items.

Wolf herring: contributed 1,886 t to the total fish landings. 65% of the total catch was contributed by gillnet followed by purse seine 20%, trawl net 10% and bagnet 6%. Size of *C. nudus* ranged between 317-720 mm and the mean size observed was 516 mm. Gravid specimens were observed during October to December. The IRI of *C. nudus* showed that the main food items were fish followed by *Acetes*, fish, ribbonfish and *Loligo* sp.

Needlefish: fishery was represented by *T. crocodilus*, *A. hians*, *S. strongylura* and *T. melanotus*, which together contributed 347 t to Maharashtra fish andings. 54% were from gillnets, purseseine 33% and trawler 12%. *Ablennes hians* size range was 350-1115 mm. Mature specimens were observed in November and December.

Demersal resources

Estimated demersal landing of Maharashtra during 2019 was 43961 t, which decreased by 48% from the previous year (84835 t). Trawls accounted for the major share of catch (77%) followed by SBN (9%), gillnets (10%). Croakers formed 37% of demersal landings, followed by threadfin breams (27%), silver pomfret (9%) and catfishes (8%).

Croakers: accounted for 8.2% (16422 t) in 2019 (45% decrease from 2018), mostly exploited by trawlers (87%), followed by bagnets (6.3%). The fishery was dominated by smaller species of *Johnieops* spp. (46%) and *Johnius* spp (41%). Large-sized croakers (*Otolithoides biauritus Protonibea diacanthus, Daysciaena albida*) are sold at a very high price due to the swimbladder export demand.

Threadfin breams: formed the 6th dominant species in the fishery landing (11862.6 t), dominated by *Nemipterus japonicus and N. randalli*. Trawl CPUE varied from 0.5 kg h^{-1}-10 kg h^{-1}. Monthly juvenile proportion ranged from, 12-96%. Mean size in fishery was 100 and 150 mm for *N. japonicus* and *N. randalli* respectively.

Pomfrets: Estimated landing of silver pomfret 4074 t. Bagnets accounted for 58% followed by gillnet (30%). Major share was caught during post-monsoon. Size range in the fishery was 70-290 mm. Estimated catch of Chinese pomfret was 89.3 t and Black pomfret, 507.5 t.

Elasmobranch: estimated elasmobranch landing during 2019 was 1786 t showed a considerable decrease from the previous year (2857 t). Sharks contributed 73%, rays 25% and guitarfish 2% of the elasmobranch landings of the state. Trawlers were the major contributors to elasmobranch landings of Maharashtra in 2019. Trawlers contributed 49%, followed by gillnets (41%) and SBN (8%).

Catfishes: accounted for 1.8% fishery (3565 t), purses seine was the major contributor with 38%, followed by trawls 36 and gillnet 22%.

Crustaceans

Total crustacean landings in Maharashtra during the year 2019 (61731.4 t) dropped by 16% compared to the preceding year. Non-penaeid shrimp formed 68.4% (42247.3 t) followed by penaeid shrimp, 29.4% (18155.6 t), crabs 1.5% (907.7 t), stomatopods 0.6% (353.5 t) and lobsters 0.1% (67.4 t) in total crustacean landings.

Total annual catch of crustaceans by trawlers was 16586.2 t with a catch rate of 4.91 kg/hr forming 19.5% of the total trawl landings. Penaeid shrimp contributed 94% (15589.7 t) followed by crabs 3.4% (566.9 t), non-penaeid shrimp 2% (326.9 t), stomatopods 0.3% (55.9 t) and lobsters 0.3% (46.7 t).

Total catch of crustaceans by bagnet was 44863.1 t with catch rate 35.1 kg/hr, 105.3 kg/haul forming 64.8% of the total bagnet fish landings from the state. In bagnet landings, non-penaeid shrimp recorded catch rate of 32.70 kg/hr (98.10 kg/haul) followed by penaeid shrimp 1.94 kg/hr (5.83 kg/haul), stomatopods 0.23 kg/hr (0.69 kg/haul) crabs 0.22 kg/hr (0.65 kg/haul) and lobsters 0.003 kg/hr (0.01 kg/haul). Non-penaeid shrimp contributed 93.2% (41805.6 t) followed by penaeid shrimp 5.5% (2483.8 t), stomatopods 0.7% (294.9 t), crabs 0.6% (275.4 t) and lobsters 0.01% (3.4 t) to total crustacean landings. *Parapenaeopsis stylifera* (48.8%) was the largest contributing penaeid shrimp followed by *Metapenaeus affinis* (21.2%), *Metapenaeus monoceros* (17.2%), *Solenocera crassicornis* (7.7%) and *Metapenaeopsis stridulans* (1.9%) in trawl landings.

1. Cephalopod landings at Newferry Wharf

Mollusc

Cephalopods landing in Maharashtra during 2019 were estimated at 14553 t with 30% decrease as compared to the previous year. Among cephalopods squids dominated the landing with 70.3% followed by cuttlefish (29.4%) and octopus (0.3%). Major fishing gear that supported the fishery were trawl net (97%) followed by purse seine (2.5%).

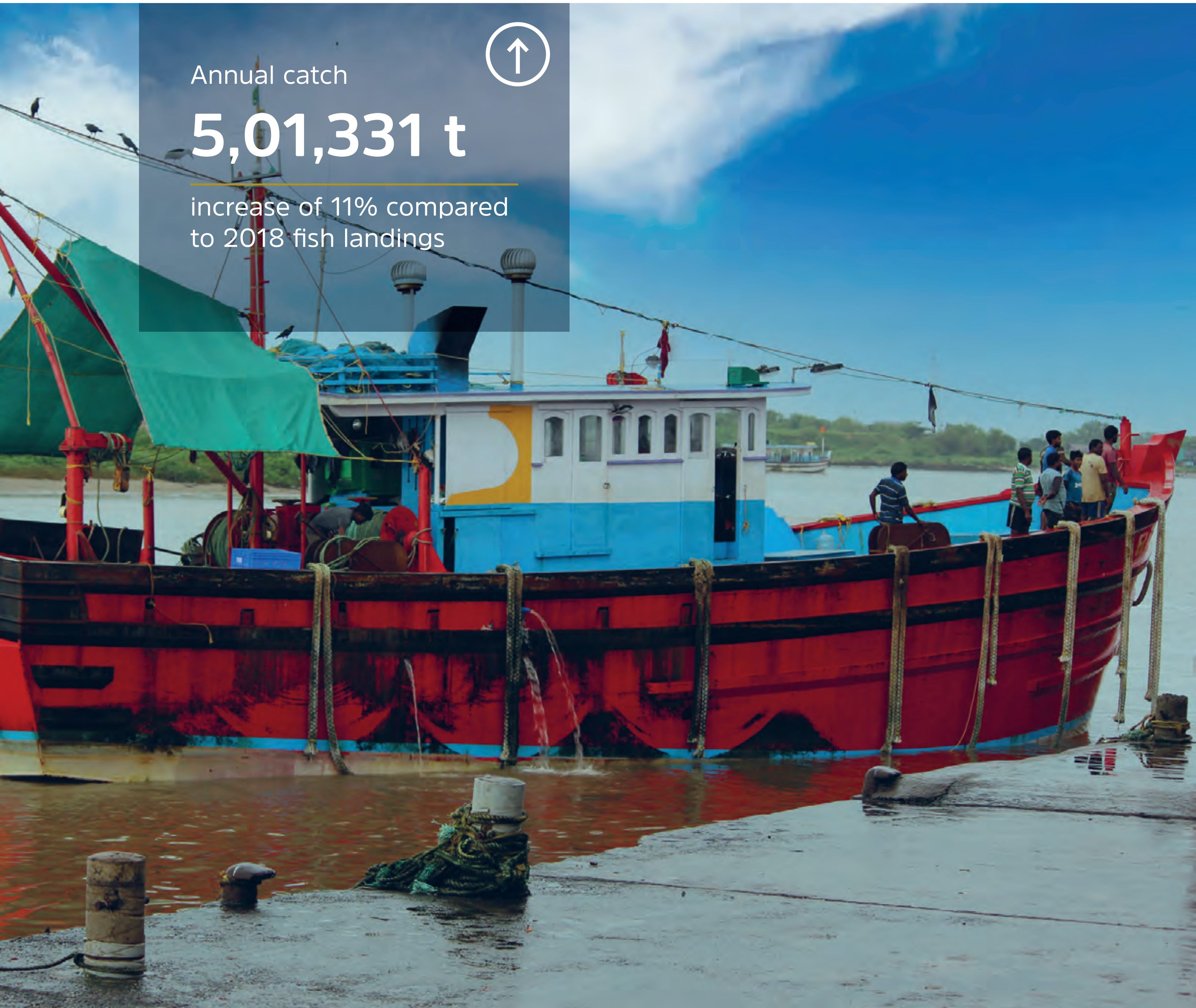
Squids: *Uroteuthis (Photololigo) duvaucelii* (99.2%), *U. (P) edulis* (0.75%), *U. (P)singhalensis* (0.04%) and *Loliolus hardwiki* (0.004%) formed the commercial fishery. Trawl was the major gear with two peaks in landing i.e. Sept.-Oct and March-April. The size range of *U. (P) duvaucelii* in the fishery was 33–210 mm (mean size 118.6 mm).

Cuttlefish: *Sepia pharaonis* (81.7%), *S. aculeata* (8.64%), *S. elliptica* (0.2%) and *Sepiella inermis* (9.5%) formed the cuttlefish fishery of the state. The fishery showed a decrease (15.8%) compared to the previous year. Size range of *S. pharaonis, S. elliptica and S. inermis* in trawl net was 175 – 320, 52 – 165 and 30 – 82 mm respectively.

Octopus: *Cistopus indicus* (92%) and *Amphioctopus marginatus* (8%) forms octopus fishery in the state. Trawl was the major gear with maximum landing from January to May. Size range of species caught in trawl net were 32 to 178 mm.

Karnataka and Goa

Research Project PEL/RMS/03



Annual catch

5,01,331 t

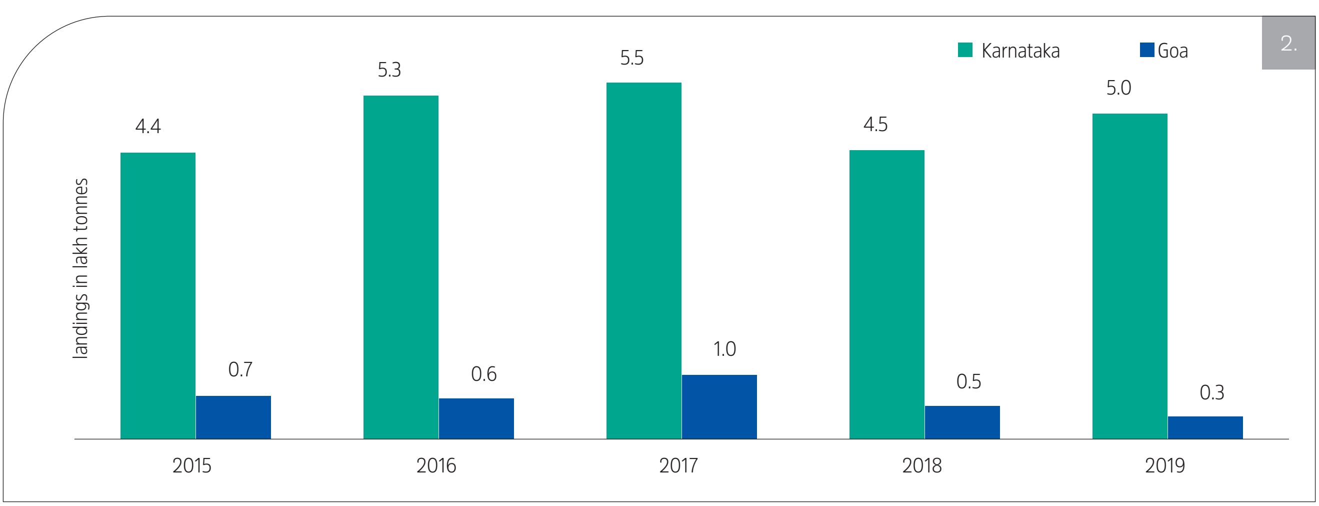
increase of 11% compared to 2018 fish landings

1. Reduce single use plastic initiative made at Mangalore Research Centre
2. Total Marine fish landing in Karnataka and Goa during 2015-2019
3. Contribution of different gears to total Marine landing in Karnataka (inner circle) and Goa (outer circle)

The landings at Karnataka during 2019 increased by 11% (501331 t) as compared to 2018 and the State stood IV among the coastal states. The landing centre and retail value of the landings during the year were estimated at ₹7118 crores and ₹10030 crores respectively. The increase was mainly due to very high landings (162398 t) of the redtoothed triggerfish (*O. niger*). The landings at Goa during 2019 (32860 t) decreased by 44% and the estimated landing centre and retail value of the landings were ₹601 and ₹874 crores respectively. Main reason for the decline was reduced fishing days with reduced catch and effort by all gears.

The contribution of the mechanized sector mainly the trawls and purse seines was around 96 and 94% respectively in Karnataka and Goa respectively. While the trawls were dominant in Karnataka, it was the purse seines in Goa.

Unprecedented high landings of the redtoothed triggerfish was recorded in both states. In Karnataka, the total catch was more than the total pelagic landings forming most dominant fish in terms of bulk. In Goa it formed the fourth most dominant fish resource of the State. Bulk of the redtoothed trigger fish was landed by trawls in Karnataka and by seines in Goa.



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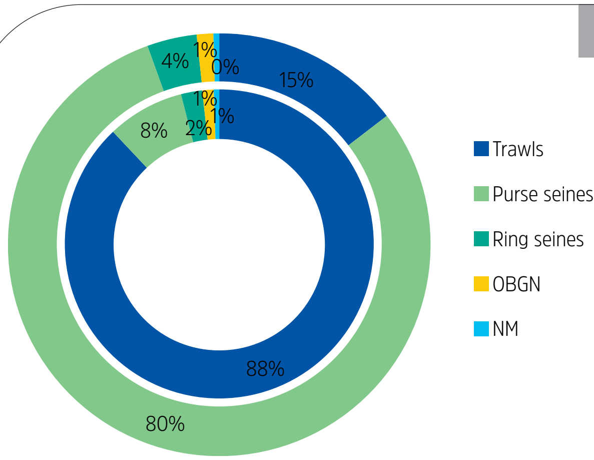


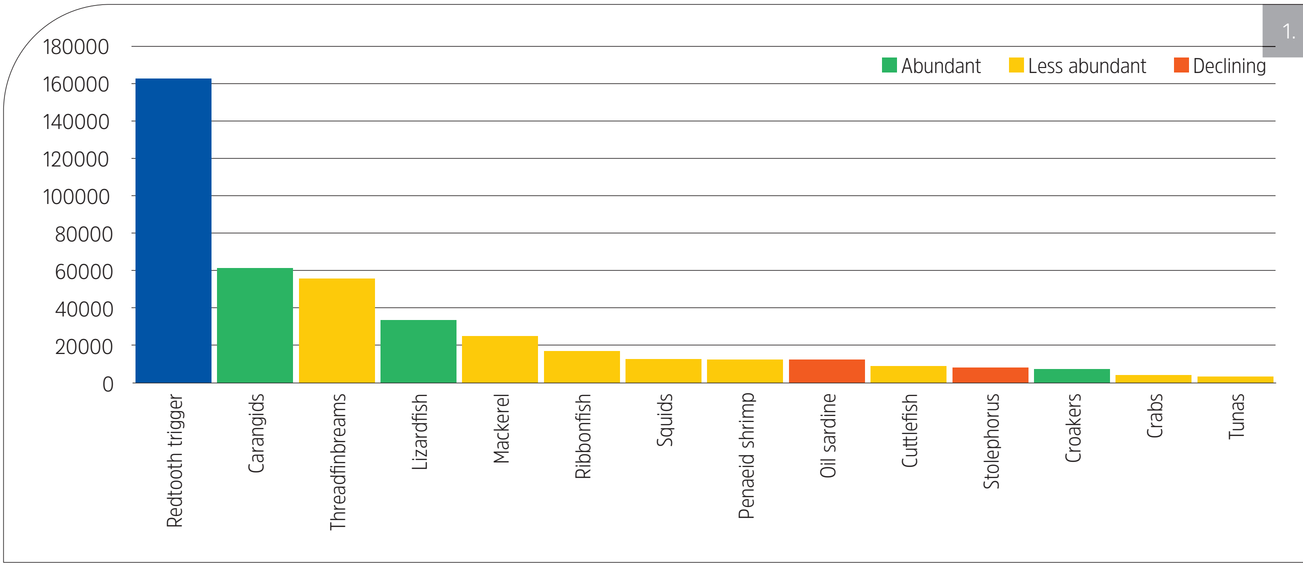
Length range, mean size, sex and maturity stages of fishes/shellfishes studied

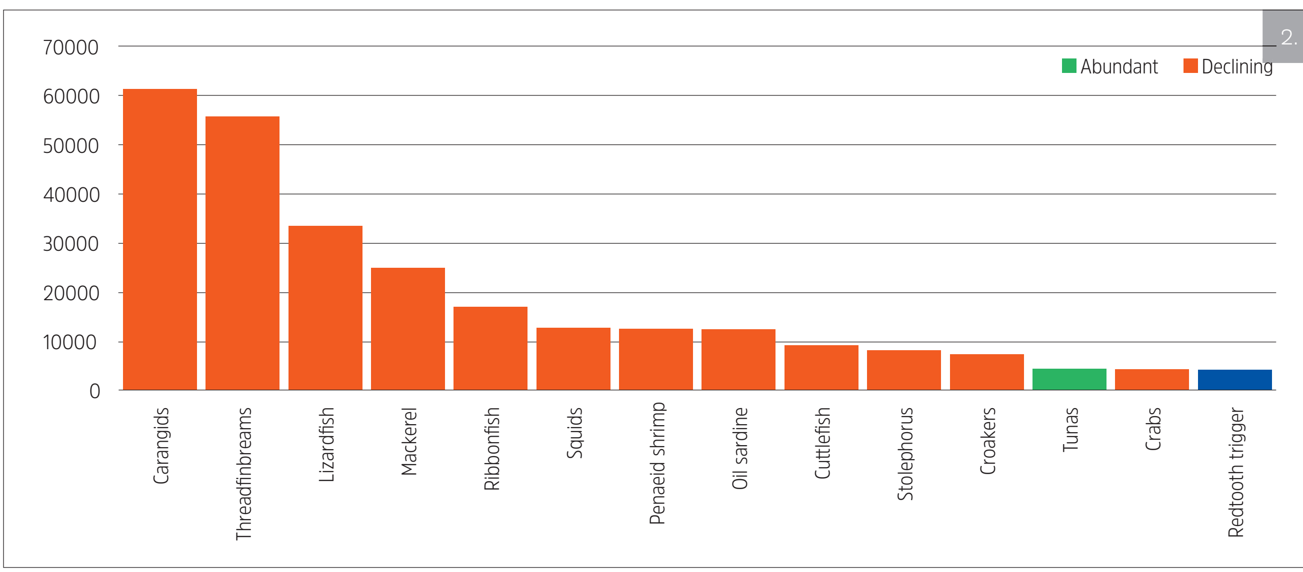
Species	Length range (mm)	Mean length (cm) 2019	Mean length (cm) 2018	Sex ratio (M:F)
Fishes				
*Sardinella longiceps**	110-212	15.8	17.5	1:0.97
*S. fimbriata**	111-202	15.2	10.5	1:0.88
*S. gibbosa**	114-196	14.3	16.3	1:1.03
*S. albella**	95-193	13.9	17.6	1:1.08
*S. brachysoma**	142-210	18.1	19.0	1:0.73
*Rastrelliger kanagurta**	85-310	19.8	19.7	1:1.30
*Trichiurus lepturus****	8-572	23.0	25.0	1:0.95
*Encrasicholina devisi**	55-126	8.5	8.6	1:0.74
*Kovala kovala**	59-125	9.7	11.5	1:1.23
*Megalaspis cordyla**	94-570	24.0	22.6	1:0.97
*Decapterus russelli**	108-233	16.5	15.8	1:1.06
*Seriolina nigrofasciata***	95-790	31.0	29.4	1:1.04
*Rachycentron canadum***	160-1730	69.0	58.0	1:1.2
*Scomberomorus commerson***	110-1900	55.0	59.0	1: 0.58
*S. guttatus***	235-810	36.0	34.0	1:1.6
*Euthynnus affinis***	171-720	39.0	36.0	1:0.91
*Auxis thazard***	215-595	39.0	35.0	1:0.55
*A. rochei***	168-318	24.0	45.0	1:1.4
*Thunnus tongol***	310-650	44.0	71.0	1:2.3
*T. albacares***	380-1460	63.0	42.0	1:1
*Sphyraena orientalis***	330-1125	50.0	25.0	1:0.2
*S. obtusata***	107-380	22.0	22.0	1:1.5
*S. putnamae***	170-910	37.0	37.0	1:1.39
*S. jello***	119-1420	33.0	38.0	1:0.8
*S. arabiensis***	453-1430	89.0	47.0	1:0.5
S. barracuda	590-1600	96.0	33.0	1:0.8
*Scomberoides commersonianus***	190-1940	58.0	38.0	1:0.92
*S. tol***	135-595	30.0	45.0	1:1.1
*S. tala***	220-567	34.0	74.0	1:3
*S. lysan***	241-580	38.0	87.0	1:0.2
*Coryphaena hippurus***	268-2150	72.0	97.0	1:2.5
*Ablennes hains***	410-1120	80.0	47.0	1:2.3
*Tylosurus crocodilus***	710-1420	104.0	17.5	1:2.3
*Elagatis bipinnulatus***	260-920	43.0	10.5	1:1.0
*Parastromateus niger**	60-570	23.2	23.2	1:1.5
*P. argenteus**	60-360	20.8	21.5	1:1.0
*Nemipterus randali**	30-290	12.1	12.2	
*N. japonicus**	40-350	14.3	13.0	1.0:1.8
*Lactarius inermis**	30-540	18.1	18.1	1:0.8
*L. lactarius**	70-250	15.05	14.7	1.0:1.0
*Otolithes cuvieri**	40 –480	23.5	21.8	1:1.2
*O. ruber**	51 –470	18.8	23.6	1:1.6
*Saurida tumbil**	60 –590	29.4	26.1	1:1.5
*S. undosquamis**	40 –490	19.0	19.0	1:1.3
*Priacanthus hamrur**	80 –380	23.5	22.4	1:1.4
Crustaceans				
Penaeid prawns				
*Metapenaeus dobsoni**	46-113	8.14	8.6	1:1.17
*Parapenaeopsis stylifera**	53-118	9.14	9.4	1:1.56
*Metapenaeus monoceros**	78-188	13.72	12.4	1:0.78
Solenocera choprai	63-113	8.83	8.7	1:1.15
Crabs				
*Portunus sanguinolentus**	46-130	9.02	9.0	1:2.87
*P. pelagicus**	31-160	8.51	8.5	1.78
*Charybdis feriatus**	41-130	8.00	8.0	1:1.28
Cephalopods				
Squids				
Uroteuthis (P.) duvaucelii	25-300	9.6	9.5	1:0.9
U.(P.) singalensis	50-285	15.9	12.0	1:0.7
U.(P) edulis	45-285	11.5	10.9	1:1
Cuttlefish				
Sepia pharaonis	50-405	20.6	18.7	
Sepiella inermis	25-100	7.0	6.2	1:1.2
Octopus				
Amphioctopus neglectus	25-110	6.2	4.9	1:0.8

*Total length, **Fork length, ***Anal length, for Cephalopods-Mantle length

Major prey components in the gut of different fishes/shrimps

Species	Major food items
R. kanagurta	*Coscinodiscus*, *Ceratium, Cladocera,* Tintinids, *Pleurosigma,*Copepod, *Foraminifera*, fish scales, semi digested fish, *Thalasiothrix,Trichodesmium, Pyrophacus*, diatom, *Ornithoceros, Peridinium,*crustacean remains, *Dinophysis, Mesosira, Ditylum, Skeletonema, Planktonium*, Amphipoda, *Nitzschia, Bacteriastriam, Detritus*, *Navicula*, naupli.
S. longiceps	*Coscinodiscus*, Copepod, *Pleurosigma, Foraminifera, Ceratium, Cladocera,* Tintinids, fish Scales, semi digested matter, semi digested fish, *Thalasiothrix,* *Trichodesmium, Pyrophacus, Diatom, Ornithoceros, Peridinium,* crustacean remains, *Dinophysis, Melosira, Ditylum, Skeletonema, Planktonium, Amphipoda, Nitzschia, Bacteriastriam, Detritus, Navicula,* naupli, *Acetes* sp. and *Bregmoceros* sp.
S. gibbosa	Copepods, amphipods, *pleurosigma, Fragilaria, Protoperidinium*, fish eggs, *Coscinodiscus, Nitzchia,* Calanoid copepods, *Skeletonema* and Nauplii.
S. fimbriata	*Cladocera,* amphipoda, Peridinium, *Ceratium, Triceratiium, Prorocentrum, Fragilaria, Coscinidiscus*, Foraminifera, crustacean remains, *Mesodinium.*
S. albella	*Ceratium, Peridinium*, Amphipoda, Copepod, *Pleurosigma,* fish eggs, crustacean larvae
E. devisi	Cladocerans, amphipods, megalopa, bivalves, semi digested fish and crustacean remains.
M. cordyla	*S. longiceps, S. waitei, E. devisi*, *Acetus* sp., *D. russelli*, Prawns,Squid and semi digested fish.
D. russeli	*Acetus* sp., *Bregmoceros* sp., *E. devisi*, *Leiognathus* sp, *L. lactarius*, squid, prawns, fish ccales and semi digested Fish.
T. lepturus	*D. russelli, E. devisi, Acetus* sp., *Saurida* sp., *Loligo* sp., *Priacanthus* sp. *N. randeli, T. lepturus*, *L. inermis* and semi digested fish.
S. nigrifasciatus	*D. russelli, E. devisi, Acetus* sp., *Saurida* sp., *Loligo* sp., *Priacanthus* sp. *N. randeli,* and semi digested fish.
S. commerson	*S. longiceps*, *D. russelli*, mackerel, *Saurida* sp., *Nemipterus* sp., squids etc.,
R. canadum	*Sphyraena* sp., soles, squilla, *D. russelli*, *Nemipterus* sp., *Stoliphorus* sp., *Platycephalus* sp., *R. kanagurta*, *O. niger*, squid, *E. diacanthus*, *Acetes* sp., crabs and *S. undosquamis*.
E. affinis	*A. rochei*, shrimps, *D. russelli*, *Nemipterus* spp., squids, cuttlefish, *Acetes* sp., digested fish.
A. thazard	*Acetes* sp., prawns, squids, semi digested fish.
T. albacares	Squids, Crabs and Semi digested fish
A. rochei	Semi digested fish
T. tongol	*L. duvacelli, D. russelli* and semi digested fishes.
S. putnamae	*Saurida* sp., *D. russelli, S. longiceps, mackerel, horse mackerel* and semi digested fishes.
S. obtusata	*R. kanagurta, Stolephorus* sp., and *D. russelli*
S. barracuda	Semi digested fishes.
S. jello	*D. russelli, E. devisi, A. hians* and semi digested fishes.
C. hippurus	*Priacanthus* sp., *E. diacanthus*, mackerel, *D. russelli, L. inermis, T. lepturus*, *O. niger*, squids, Octopus and semi digested fish.
S. commersonianus	*T. lepturus, D. russelli, E. devisi, Loligo spp. L. inermis, S. choprai, Belone spp. S. commersonii, S. eliptica, N. japonicus, Bregmoceros*, R. *kanagurta*, anchovies and digested fish.
S. tol	*E. devisi, Stolephorus* sp., *Bregmoceros* sp., *Acetes* sp. and *L lactarius.*
S. tala	*Loligo* sp. and semi digested fishes.
A. hians	*D. russelli, E. devisi* and semi digested fishes.
T. crocodilus	*N. randalli,* squid and semi digested fishes.
Otolithes cuvieri	*E. devisi, Bregmoceros* spp., *Acetes* spp., Shrimp
Otolithes ruber	*P. stylifera,* shrimps, *Acetes* spp., *E. devisi, Bregmoceros* spp., *S. waitie*
Saurida tumbil	*E. devisi*, Squid, *D. russelli, Uroteuthis duvauceli,* Anchovy, *R. kanagurta, Nemipterus*spp., *Loligo* spp., *N. japonicus,*
Saurida undosqamis	*E. devisi, Nemipterus japonicus, Acetes* spp., *Uroteuthis duvauceli, Saurida* spp.
Priacanthus hamrur	*Acetes* spp., Shrimps, *N. japonicus, Apogon* spp.
M. dobsoni	Fish, crustacean and mollusc remains, sand/mud, algal debris formaminiferans, polychaetes
P. stylifera	Fish, crustacean and mollusc remains, sand/mud, algal debris formaminiferans, polychaetes
M. monoceros	Fish, crustacean and mollusc remains, sand/mud, algal debris formaminiferans, polychaetes
S. choprai	Fish, crustacean and mollusc remains, sand/mud, algal debris formaminiferans, polychaetes





1. Landing pattern of dominant species in Karnataka and its rapid stock status in 2019
2. Landing pattern of dominant species in Goa and its rapid stock status in 2019

Odonus niger, during the reporting period was treated as a separate resource to avoid a skewed picture of the contribution of different groups. The fishery and biology of 59 species of fin fishes and shellfishes were studied during the year.

The focused study to determine the best trawling practice for the country, collected questionnaire-based data on trawling operation, catch/bycatch, juvenile percentage in trawl fisheries in all maritime states. The developments and status of trawling practices in Northwest, Southwest, Southeast and North east of India were documented and time line of trawl development depicted. A model document on the evolution of trawl fishery including status of trawl fishery in Andhra Pradesh, Karnataka, Gujarat and Maharashtra was prepared based on multiple stake holder workshops/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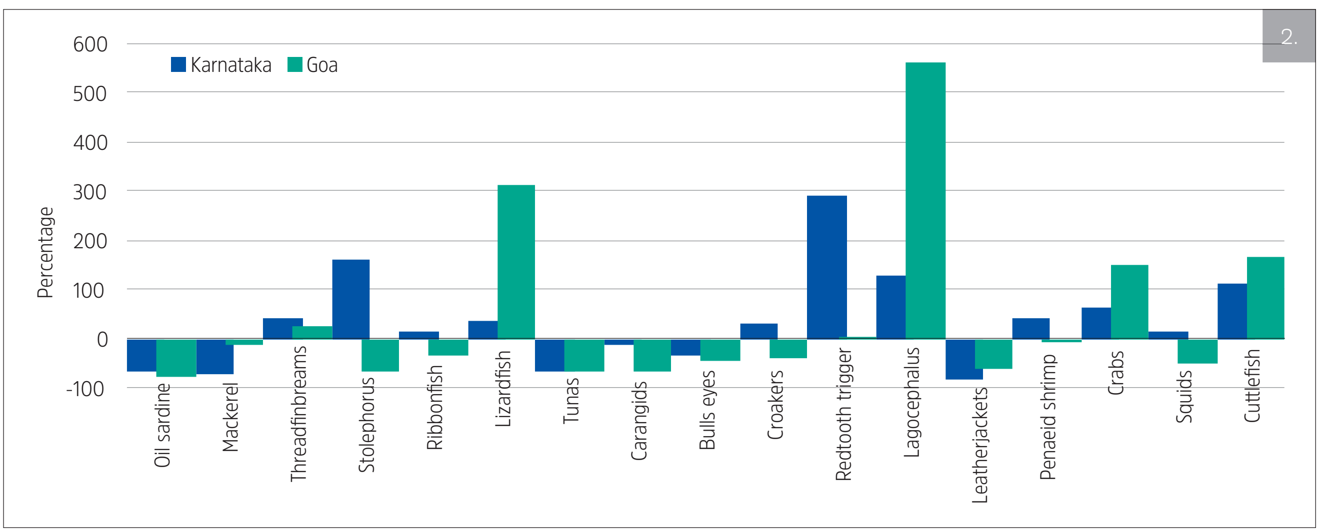

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discussions. A preliminary workshop on socio- economic data analysis was conducted by the experts and protocol for National level data analysis was finalized.

Stock status of the dominant species/ groups landed in Karnataka and Goa were estimated using the Rapid Stock Status Assessment (Mohamed *et al*,2010).

Pelagic fishes (1,57,324 t t) forming 39.1% of the total landings in Karnataka recorded a decline of 38.5% as compared to 2018. Similarly, in Goa the catch (23,653t) formed 72% of total catch, a reduction of 49.3%.

Clupeids (Sardines, white sardine), Engraulids (anchovies), Scombroids (mackerel, tuna and seerfish), Carangids (scads, horse mackerel, black pomfret and other carangids), ribbonfish, barracudas and fullbeaks were the dominant groups contributing to the fishery.

An increase in the mean length of several pelagic fishes during the year was observed. The juvenile

1. Motorised gillnetters at Mangalore
2. Trends in landing of major resurces in Karnataka and Goa as compared to 2018
3. Contribution of pelagic, demersal, crustacean, molluscs and red toothed triggerfish to total marine fish landing in Karnataka and Goa
4. Contribution of penaeid shrimps, crabs and stomatopods in Karnataka (inner circle) and Goa (outer circle)
5. Major Pelagic species/ groups contributing to the fishery in Karnataka
6. Major pelagic species/ group contributing to the fishery in Goa
7. Major demersal species/ groups contributing to fishery in Karnataka

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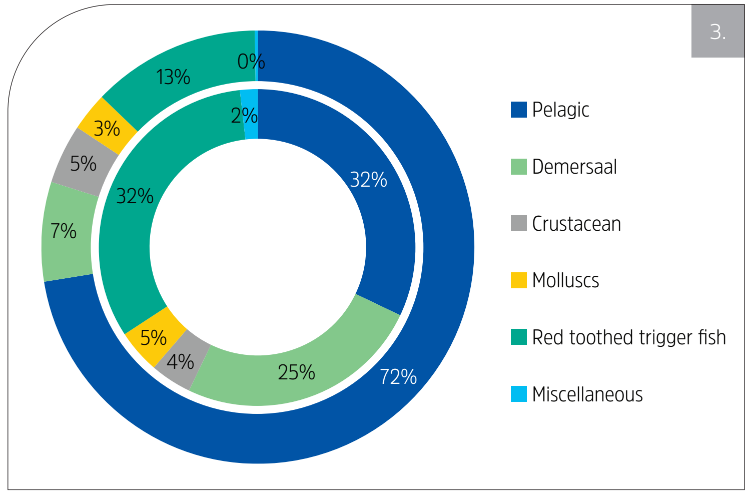

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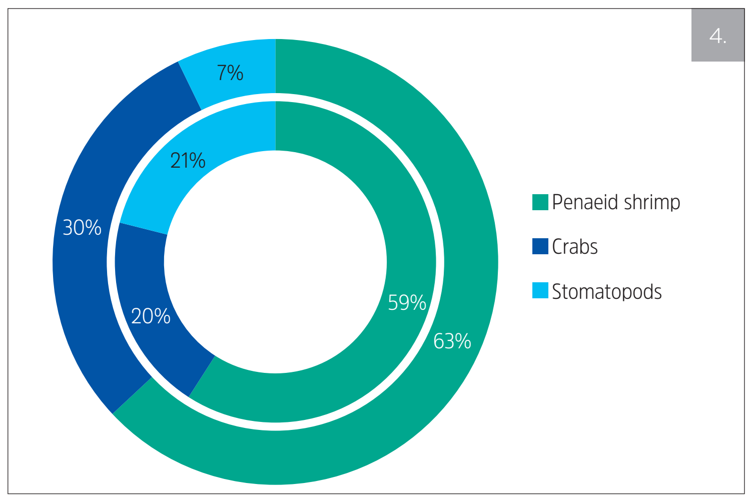

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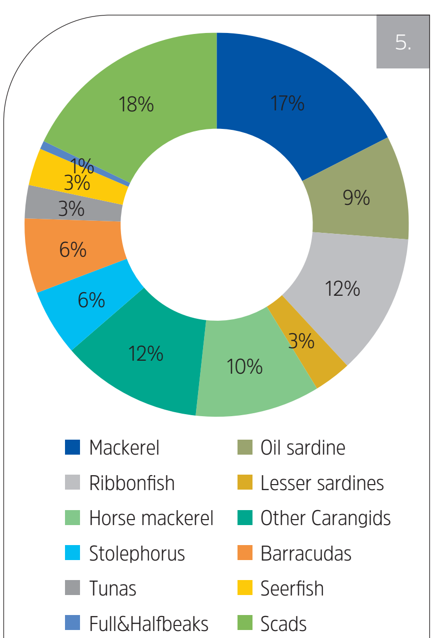

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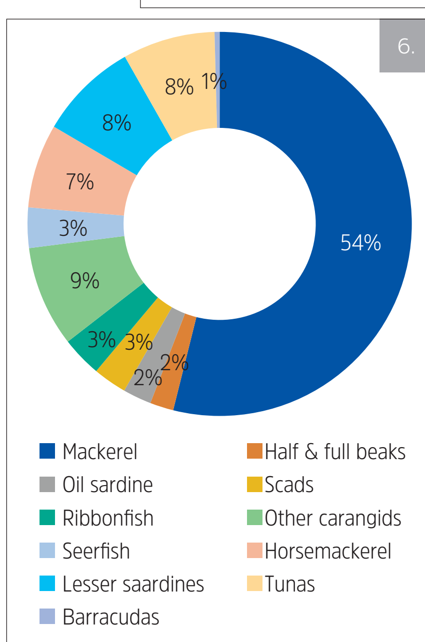

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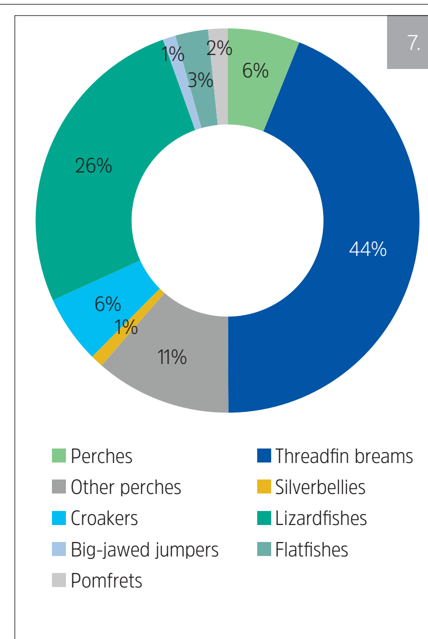
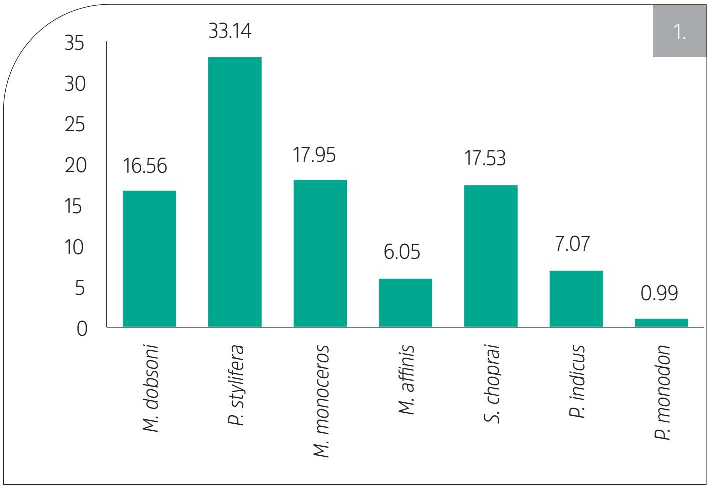
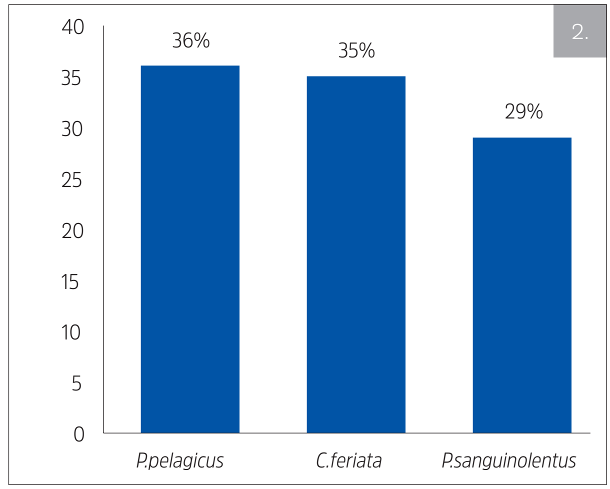
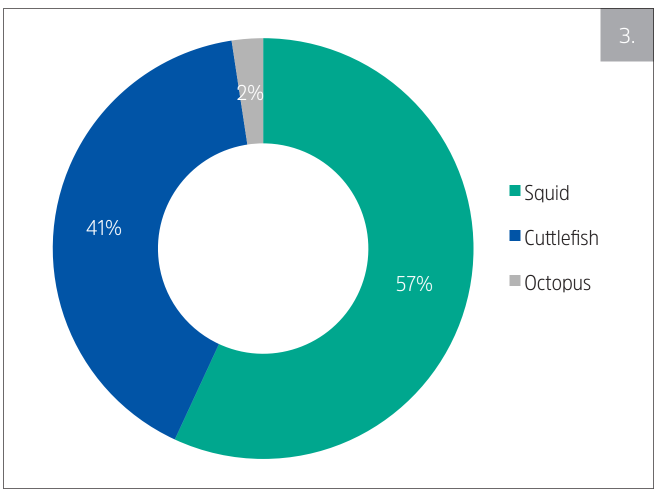
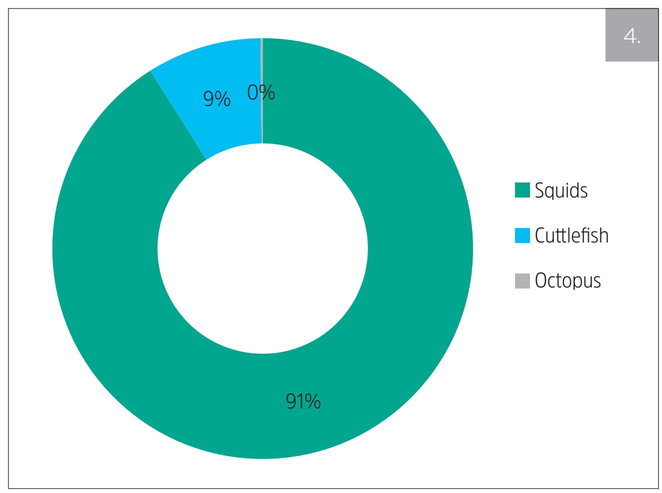










composition of important fish and shellfish species were estimated based on the Minimum Legal Size (MLS). The percentage of juveniles (in numbers) of important fishes and shellfishes landed by different gears in Karnataka was estimated.

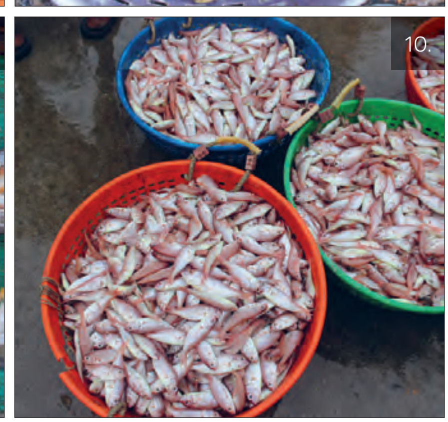
Demersal fishes (1,29,073t) formed 26% of the total catch in Karnataka and 8% (2597 t) in Goa. Perches (threadfin breams, bull's eyes, rockcods, and other perches), lizardfishes, croakers, soles, silverbellies, and big jawed jumpers were the dominant groups. Demersal landing this year registered an increase of 14.1% in Karnataka and steep decline of 50.6% in Goa.

Crustaceans formed 4.1% (21,111 t) and 4.4% (1461 t) of the marine landings in Karnataka and Goa and the landings this year is 33.4 and 15.2% more respectively as compared to last year. Penaeid shrimps, crabs, stomatopods and lobsters contributed to the crustacean catch.

Molluscs (22,310 t) were mainly constituted by cephalopods (22,275 t-squids, cuttlefish and octopus) comprising 4.5% of the total landings of Karnataka.

In Goa, Molluscs (945t) comprised only of cephalopods contributing to 2.9% of total catch. Karnataka

1. Species composition of penaeid shrimps in Karnataka during 2019
2. Species composition of crabs landed in Karnataka during 2019
3. Group wise cephalopod landings in Karnataka
4. Groupwise cephalopod landings in Goa
5. Crabs landed at Mangalore Bunder
6. *Saurida* spp.
7. Bull's eye
8. Clams marketed at Mangalore Bunder
9. *Otolithes* spp
10. *Nemipterus* spp
11. Squid landings



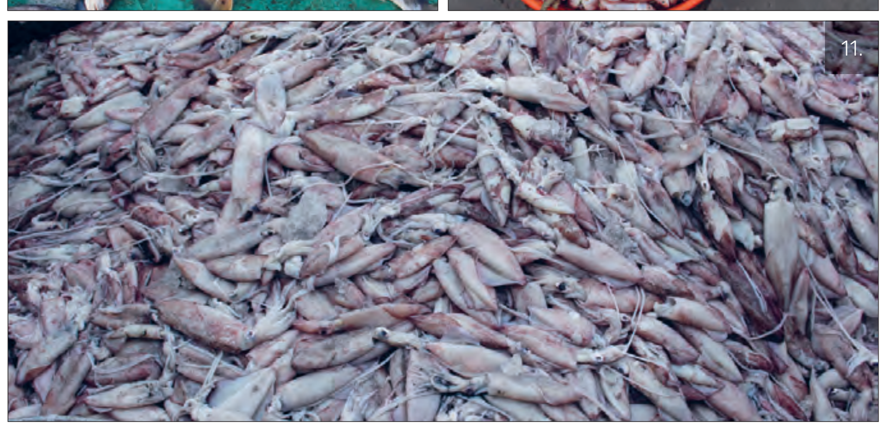


Table.3. Cost and earnings of Multi-day trawlers and Mech. purse seiners operating at Mangalore Fishing Harbour, Karnataka

Particulars	Average for January-June, 2019	
	Multi-day Trawlers	Mech. Purse seine
Total operating costs (₹)	563020	238574
Gross revenue (in ₹)	651733	394204
Net operating income (₹) (7)-(6)	88713	155630
Operating ratio (total operating cost/gross revenue)	0.86	0.60
Labor productivity (in kg) (catch/crew/trip)	956	482.2
Total Input costs (Fuel+Auction+Others)	373521	169059
Input-output ratio = (Input costs/gross revenue)	0.57	0.42
Gross value added=(Net operating income + crew share)	236244	222328
GVA as a percent of gross revenue	0.36	0.56

1. Redtoothed triggerfish
2. *Stolephorus* spp

recorded an increase of 38% and Goa a decrease of 48% as compared to 2018. Squids dominated the cephalopod catch in both states.

Cost and earning data pertaining to mechanized trawlers, purse seiners and gillnetters collected and analysed from Mangalore landing Centre is provided in Table 3.

Advisories on sustainable marine fisheries practices were provided to Directorate of Fisheries, Government of Karnataka regularly and based on this the DoF has

- Issued order on MLS for 19 marine fish species
- Supplied 35 mm square mesh cod ends to trawl boat owners.
- Reissued the ban orders on operation of pair trawls and light-based purse seining.
- Policing was enhanced, fines imposed on fishers for noncompliance.

Fishery economics

- Cost and earnings data pertaining to mechanized trawlers, purse seiners and gillnetters were collected from Mangalore landing centre of Dakshina Kannada District of Karnataka.
- Data was collected at monthly intervals covering 9 days/month. Log sheets were given to writers of boats who maintain detail accounts of fishing vessels on a per trip basis.

Kerala & Lakshadweep

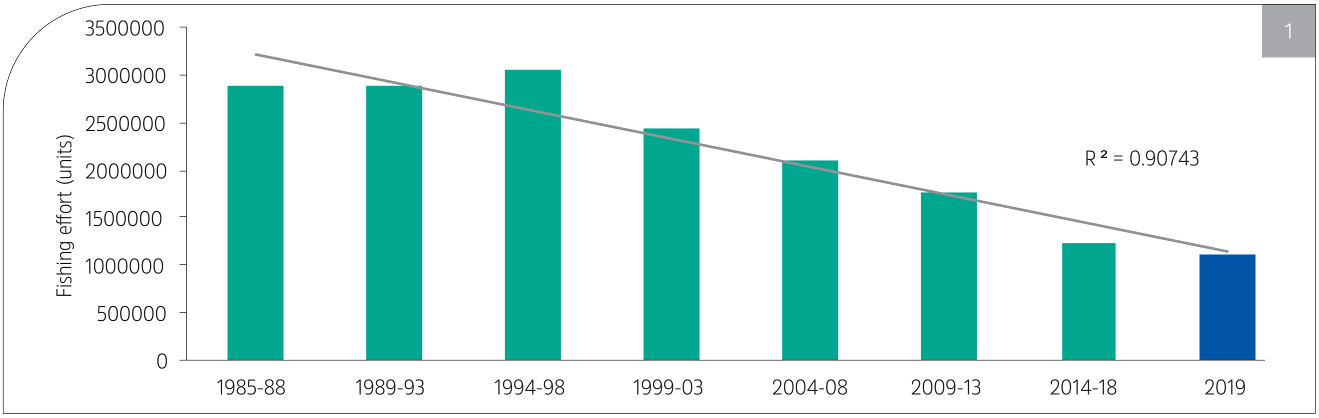
Research Project: DEM/RMS/07 & DEM/RMS-SUB/07

Landings of *Odonus niger* at Munambam Fisheries Harbor, Kerala

Annual catch

5,43,836 t

decrease of 15.3% catch compared to 2018



1. Changes in fishing effort expended along the Kerala coast during last 25 years
2. Mackerel landings by inboard ring seine along Kerala coast
3. Ribbonfish landings at Cochin Fisheries Harbour
4. Threadfin bream landings at Munambam Fishing Harbour

The total marine fish landings in Kerala during 2019 were 5,43,836 t, 15.3% lower than that of the previous year (2018). About 77.7% of the catch was landed by mechanized gears and 21.4% by motorized units. Major resources in the catch were *Stolephorus* (12.3%) followed by *Odonus niger* (11.5%), penaeid shrimp (7.9%), oil sardine (8.0%), Indian mackerel (7.0%) lesser sardines (6.0%) and threadfin breams (5.0%). Pelagic finfishes dominated in the landings with a share of 51.4%, which was 26.8% lower than that of the previous year's estimated pelagic catch. Demersal finfishes constituted 16.8% of the total marine fish landings of Kerala with estimated landings of 91,483 t, which was 24.2% lower than that of the previous year's estimates.

There was a considerable decline in oil sardine and Indian mackerel catches in Kerala with estimated landings of 44,320 and 40,554 t respectively registering a decline to half of the landings of the previous year. However, the mean size in the catch of oil sardine was 170 mm which was higher than the estimated length at first maturity of 147 mm. The length range of Indian mackerel in the fishery was 110-280 mm with a mean size of 220 mm, which is well above MLS and size at first maturity. However, the catch of the lesser sardines increased by 98.7% and that of *Stolephorus* increased by 30.3% compared to that of 2018. The landings of ribbon fishes also showed 78.4% increase (27449 t). There was 62% decline in the landings of scads with an estimated catch of 16,403 t compared to 42,266 t in 2018.

Among the demersal finfishes, the dominant resource was threadfin breams with annual landings of 28,001 t which formed 30.6% of the total demersal landings of the state, which was followed by lizardfishes (19.1%), soles (16.8%) and other perches (11.4%). There was considerable decline in the landings of threadfin breams (-47.7%), big jawed jumper (-56.6%), pigface breams (-53.7%) and croakers (28.0%) in 2019 compared to that of the previous year. The catch of silver pomfrets (+80.8%), lizardfishes (+40.2%), snappers (+41.8%) increased considerably. There was a marginal decline (-9.7%) in the landings of elasmobranchs in 2019 (3143 t), of which sharks contributed 58.8%, followed by rays (40.1%). Sixteen species of sharks were observed, of which *Carcharhinus falsciformis* (53%) was the dominant one with an annual mean length of 152 cm. The mean length of


2.


3.


4.

falsciformis and *Galeoserdo cuvier* in the landings were considerably below their size at first maturity.

Crustacean resources contributed 10.5% of the total marine fish landings of Kerala with estimated landings of 56,875 t, which was 12.3% lower than the previous year's estimates. About 82.0% was contributed by penaeid shrimp, followed by crabs (9.9%). The non penaeid shrimp landings declined to half of that of the previous year and stomatopod landings declined by 60%. The average annual deepsea shrimp landings (9865 t) reduced by 24% from the previous year, of which penaeids formed 48%.

A total of 39,238 t of molluscs were landed in Kerala which formed 7.2% of the total marine fish landings of the state. The cephalopod landings were 37,124 t, which was 26% lower than that of the previous year. About 85% of the landings were contributed by multiday trawlers. Squids (49.2%) dominated the catch followed by cuttlefish (34.5%) and octopus (15.8%). In case of major squid *U(P). duvaucelii,* the mean lengths were marginally below the optimum length of capture.

During 2019, the stoichiometric dynamics of selected dissolved inorganic nutrient elements *viz.* nitrogen, phosphorus and silicon were

1. Fishing locations of *Odonus niger* along Kerala coast
2. Diet of *Odonus niger* landed along the Kerala coast
3. Impact of juvenile fishing on the stock and recruitment of the lizardfish *Saurida tumbil*
4. Squid landings from Cochin Fisheries Harbour
5. Juvenile sharks landed at Cochin fisheries harbour

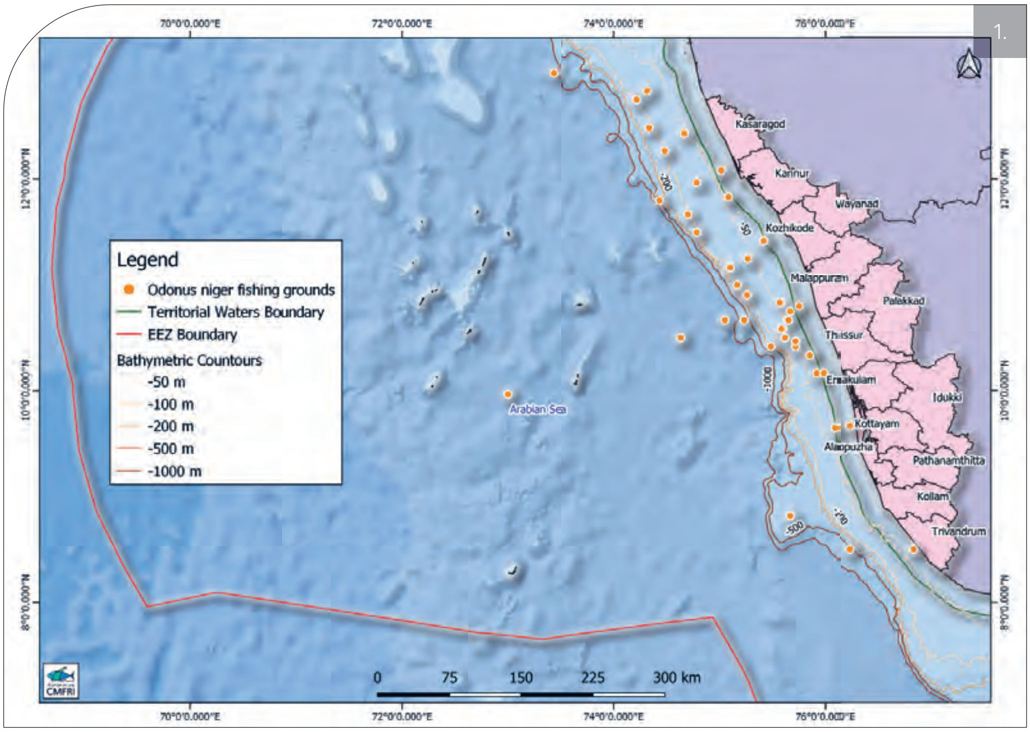
analysed in the surface waters off Kochi, at different depth locations. The relationship between the relative quantities (as molar ratios) of dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP) and dissolved inorganic silicon (DSi) taking part in the biogeochemistry of coastal marine ecosystems, has bearing with the phytoplankton growth, population and community structure in the ecosystem. At 5m depth, chlorophyll *a* and chlorophyll *b* were positively correlated DSi : DIN. Net primary production here was positively correlated with chlorophyll a and DIN : DSi. Total phytoplankton (number of cells per litre) was found to have significantly positive correlation with DIN : DIP and DSi: DIP at ratios 5m depth. At 20 m depth, diatoms were found to be positively correlated with DIN:DSi ratio and with chlorophyll *c*. Similarly, total phytoplankton count were having positive correlation with DIN : DIP and with DSi : DIP.

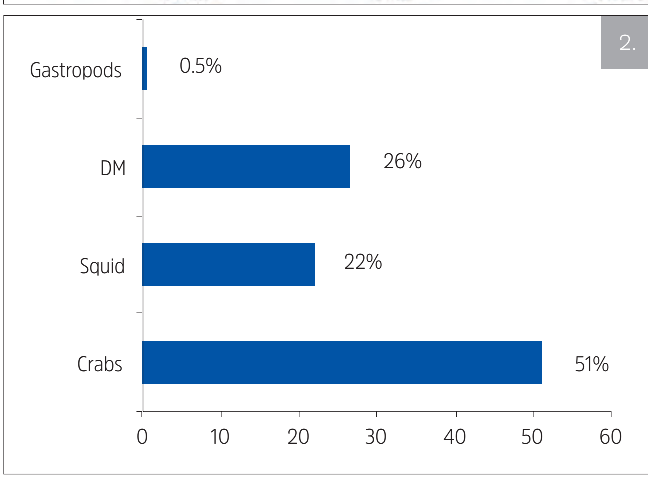
The gross value of marine fish landings in Kerala for the year 2019 was ₹12,387 crores at landing centre level and ₹17,515 crores at retail level. The average fishermen's share in consumer's rupee was 70.7%, which varied from 50% for goatfishes and *Stolephorus* to 84.9% for squids.

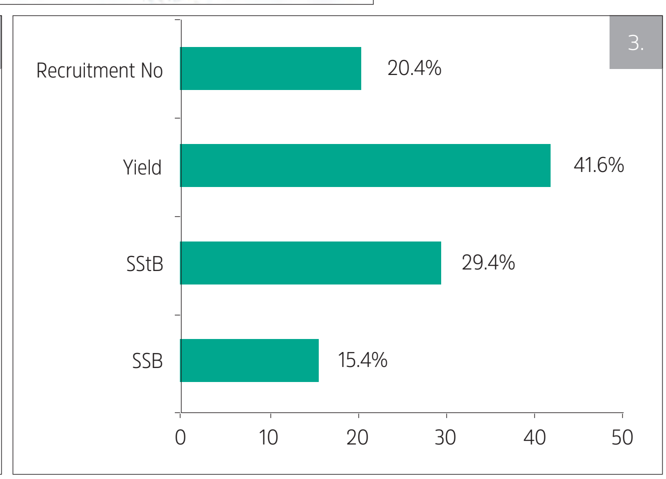
Multiday trawlers with high speed engines recorded the highest gross revenue and net operating income. However, their economic efficiency were lower than that of the previous year with low rate of return and high input output ratios.

Characteristics of *Odonus niger* fishery during 2019: The unusual fishery for *Odonus niger* (red-toothed trigger fish–*klathi)* along the Kerala coast continued throughout the year with high landings of the species noticed during the first and second quarter of the year, mainly targeting fish meal industry. Total harvest in 2019 was 62,781, which is 125% higher than that of the previous year. About 90% were caught by multiday trawlers with a CPUE of 2-6 t/unit. Length range in the catch was 11-24 cm (mean length-15.9 cm) and all the individuals in the sample were immature. The resource was caught all along the coast and the locations were mapped in GIS platform. Gut content analysis indicate that the species is a bottom feeder predating on crabs (51%), squids (22%) and other deepsea fishes and gastropods.

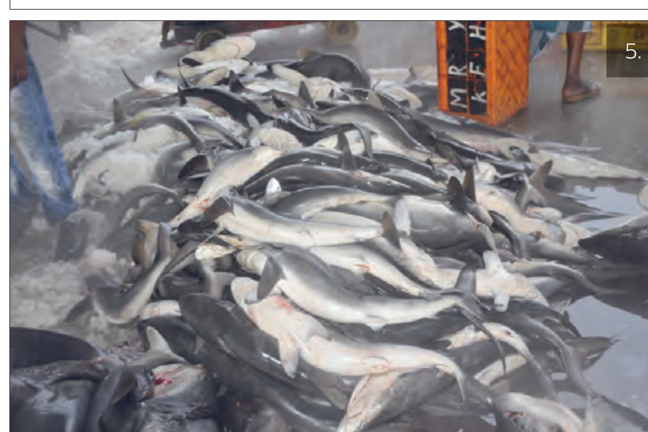
Impact of MLS regulations in the state: Implementation of MLS regulations along the Kerala coast showed its continued impact with reduced harvest of juveniles of commercially important finfishes and shellfishes during 2019 compared to that of 2018. However, there were incidences of juvenile harvest of the species *Nemipterus randalli* (5-30%) during the first and last quarters of the year and *Saurida undosquamis* (5-30%) during the last quarter, mostly by mechanized multiday trawl units. The estimated economic loss was ₹38 crores for *N. randalli,* ₹32 crores for *S. undosquamis.* There was high incidence of juvenile landings of the sharks *Carcharhinus falciformis* and *Galeocerda cuvier* along the Kerala coast during 2018, which do not come under MLS regulations in the state. However, the juvenile composition in the annual catch of *C. falciformis* declined during 2019 compared to that of the previous year with 66% of the total species catch consisted of individuals below the reported size at first maturity, with the highest juvenile


1.
Legend
Odonus niger fishing grounds
Territorial Waters Boundary
EEZ Boundary
Bathymetric Countours
-50 m
-100 m
-200 m
-500 m
-1000 m
Arabian Sea
Kasaragod
Kannur
Wayanad
Kozhikode
Malappuram
Palakkad
Thrissur
Ernakulam
Idukki
Kottayam
Alappuzha
Pathanamthitta
Kollam
Trivandrum
0 75 150 225 300 km
70°0'0.000"E
72°0'0.000"E
74°0'0.000"E
76°0'0.000"E
12°0'0.000"N
10°0'0.000"N
8°0'0.000"N


2.
Gastropods 0.5%
DM 26%
Squid 22%
Crabs 51%
0 10 20 30 40 50 60


3.
Recruitment No 20.4%
Yield 41.6%
SStB 29.4%
SSB 15.4%
0 10 20 30 40 50


4.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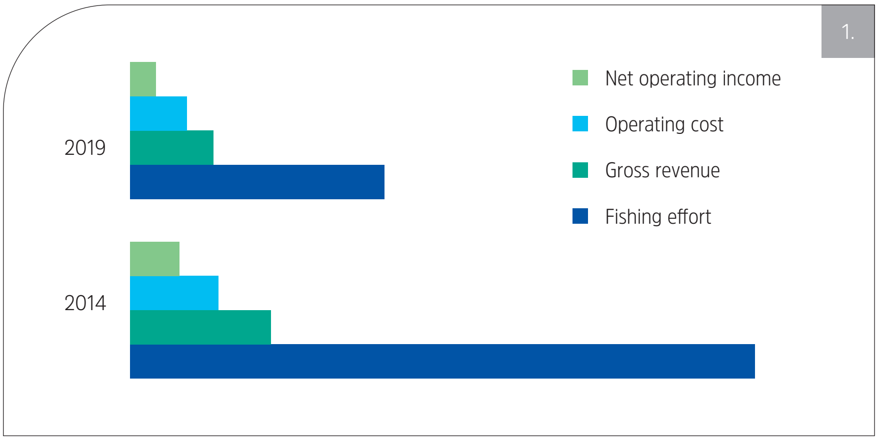


landings during August (38%) followed by October (14%) and November (13.5%). The estimated economic loss due to juvenile shark (*C. falciformis)* fishing was ₹65.1 crores. Overall, there was a considerable reduction in the juvenile harvest of MLS listed species along the Kerala coast in 2019 compared to 2018. The biological impact of the juvenile fishery also were assessed and found that it significantly affects the spawning stock biomass as well as future recruitment of the species to the fishery.

Decline in Oil sardine catch–Socio-economic impact: The impact of decline in oil sardine catch to the fishery economy and livelihood of the marine fishermen of the state was studied. The annual average decline in oil sardine landings in Kerala during 2010-19 period was 20.33% whereas the decline in gross value at landing centre level was 11.60% due to the huge price rise at landing centre's and retail markets. The socio-economic impact was assessed based on data collected from 190 fishers in Ernakulam, Alappuzha and Kollam districts. The gross revenue and net operating income for outboard ring seiners (OBRS) reduced by 50% compared to that of the previous years. The OBRS fishers in Alappuzha were the worst affected with a decline in average net operating income per fishing trip by 50.3% during 2014-19. The average days of employment in 2019 were merely 133 days. Only 12% of the oil sardine fishers had options for alternate employment during offseason

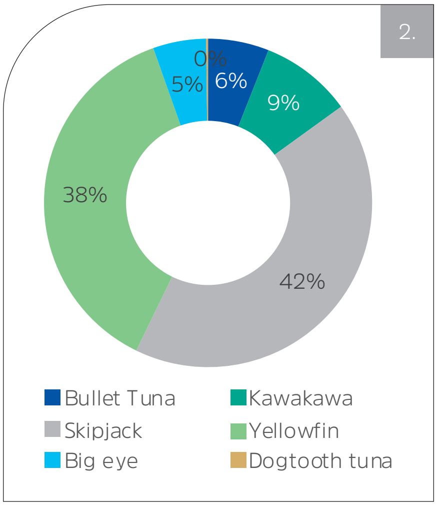
Fish landing in Lakshadweep–Trends and Interventions

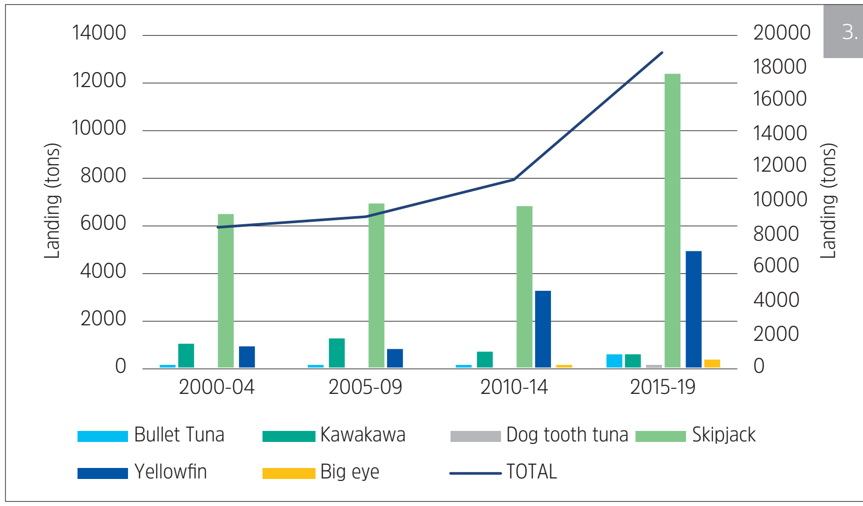
The Lakshadweep Administration follows census method of data collection wherein fish landing by every fishing unit (small or big) across various fisheries on all days in a calendar month are noted through field data collectors. The project evaluated this practice and found needing several improvements to have a scientifically robust fish landing data. Suggestions for putting in place a better data collection system has been made to the Department of Fisheries, Lakshadweep. Till such time, the data collected and reported by the Department of Fisheries as above shall be used for the analysis.

Fish landing in Lakshadweep during 2019 was 22,929 t recording decline by 18% over the previous year (27,932 t). Tuna (19,444 t) with 85% of the total landing is the major resource landed. Other resources were reef associated fishes and other large pelagics. Among the tunas, the oceanic resources constituted 85% and neritic 15%; with the skipjack (42%) and the yellowfin (38%) dominating the catches. Tuna landing has been increasing steadily over last 20 years with a very steep increase in the last five years. Yellowfin has made notable improvement in its contribution in the last ten years. Surge in fishing effort by way of increase in fishing crafts, capacity of crafts and duration of fishing coupled with development of anchored Fish Aggregation Devices (aFADs) fishing as well as value chain improvements (market) are reason for this swift increase in landing.

Towards science-based estimation of fish landing in Lakshadweep

Consultations were made with the Department of Fisheries for improvement of the fish landing data collection and estimation practice followed by the Department.





1. Socio-economic analysis of decline in oil sardine catch along the Kerala coast
2. Species composition of tuna fisheries in Lakshadweep during 2019
3. Trend of tuna landings in Lakshadweep in the last 20 years

Deficiencies of the present data collection and estimation protocol were apprised and were suggested to follow a sampling based methodology in place of census method being carried out with limited enumerators leading to poorer coverage. Sampling based data collection methodology has been developed and is being reviewed before finalisation after consultations during 2020. Meanwhile, the Department was suggested to continue the existing data collection methodology with trained manpower and revised data collection schedules. A three days training on `Collection and Estimation of Fish Landing Data' was organized from 1st May to 3rd May 2019 at Kavaratti for the benefit of the officials of the Department, especially the Field Investigators. Besides officials, 12 Field Investigators with background of graduation in fisheries sciences/ aquaculture attended the training.

Monitoring the bycatch in tuna fisheries

Ecological impacts of pole and line skipjack fisheries and handline yellowfin fisheries in Lakshadweep along with their associated livebait fisheries were studied by onboard observation. The studies reiterated the low impact of these two unique fisheries on the ecosystem in terms of bycatches. Livebait for pole and line fishery was predominantly done in lagoons with major catches being blue sprat and silver sprat and the bycatch formed nearly 6% of total livebait catch. The pole and line fishery catch comprising of skipjack, yellowfin and neritic tunas constitute nearly 97% of the catch and the skipjack alone constitute nearly 75% of the catch. Non-target but commercially valuable species such as the rainbow runner, mahimahi, billfishes, wahoo, sharks and trigger fishes constituted 3% only. Most of the bycatches were from the fishing events near the aFADs (42%) followed by open free schools and free schools near convergence areas. Livebait for handline yellowfin tuna fishery were mainly done in outer reef areas because of the habitat choice of the preferred baits such as fusiliers and trigger fishes; and bycatch constituted about 8% of total livebait catch. Yellowfin tuna constituted nearly 93% of the catch in handline fisheries and the major bycatch were billfishes, mahimahi, rainbow runner and skipjack tuna. Direct interaction with fishing gear in any of the

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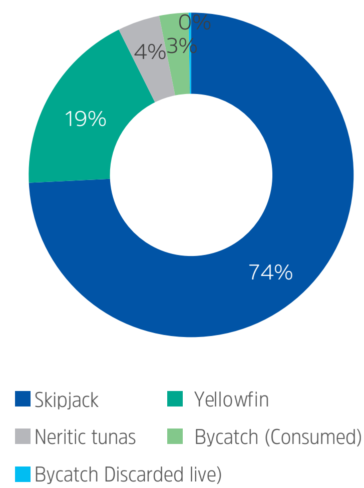

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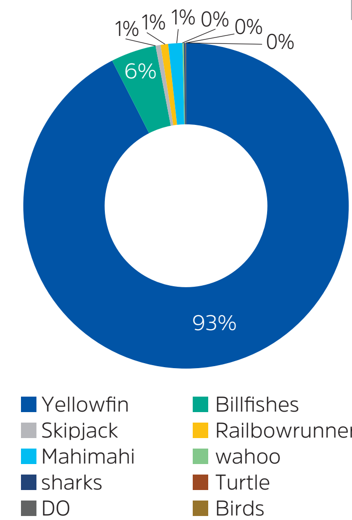


1. Catch composition in P & L tuna fishery of Lakshadweep
2. Catch composition in handline tuna fisheries of Lakshadweep

fisheries including livebait fisheries of Endangered Threatened and Protected (ETP) species constituted less than 0.01% of the total catch in both fisheries. These were the instances (three instances) of sooty tern (*Onychoprion fuscatus*) inadvertently getting hooked while feeding on the livebait casted from pole and line fishing vessel and an instance of hawksbill turtle (*Eretmochelys imbricata*) was hooked in a yellowfin handline. In all the instances, the ETP species were released quickly and safely back to the sea.

Monitoring the livebait fisheries

The livebait fisheries for tuna pole and line and handline fishing were studied for the bait diversity and abundance, livebait use patterns, bait use efficiency etc. with focus on Agatti and Kavaratti atolls during the year under report. The Lakshadweep Livebait Fisheries Management Plan (LLFMP) was published by the Director, ICAR-CMFRI as a Policy Series Publication of CMFRI (No.12) during September, 2019. The Department of fisheries, Administration of the U.T. of Lakshadweep notified the Plan as the Livebait Fisheries Management Plan of the U.T. of Lakshadweep in its Notice F. No. 49/02/2017-Fy Tech. /601 dated 18th September, 2019. The project continues to hold hands with the Department in rolling out the plan as envisaged.

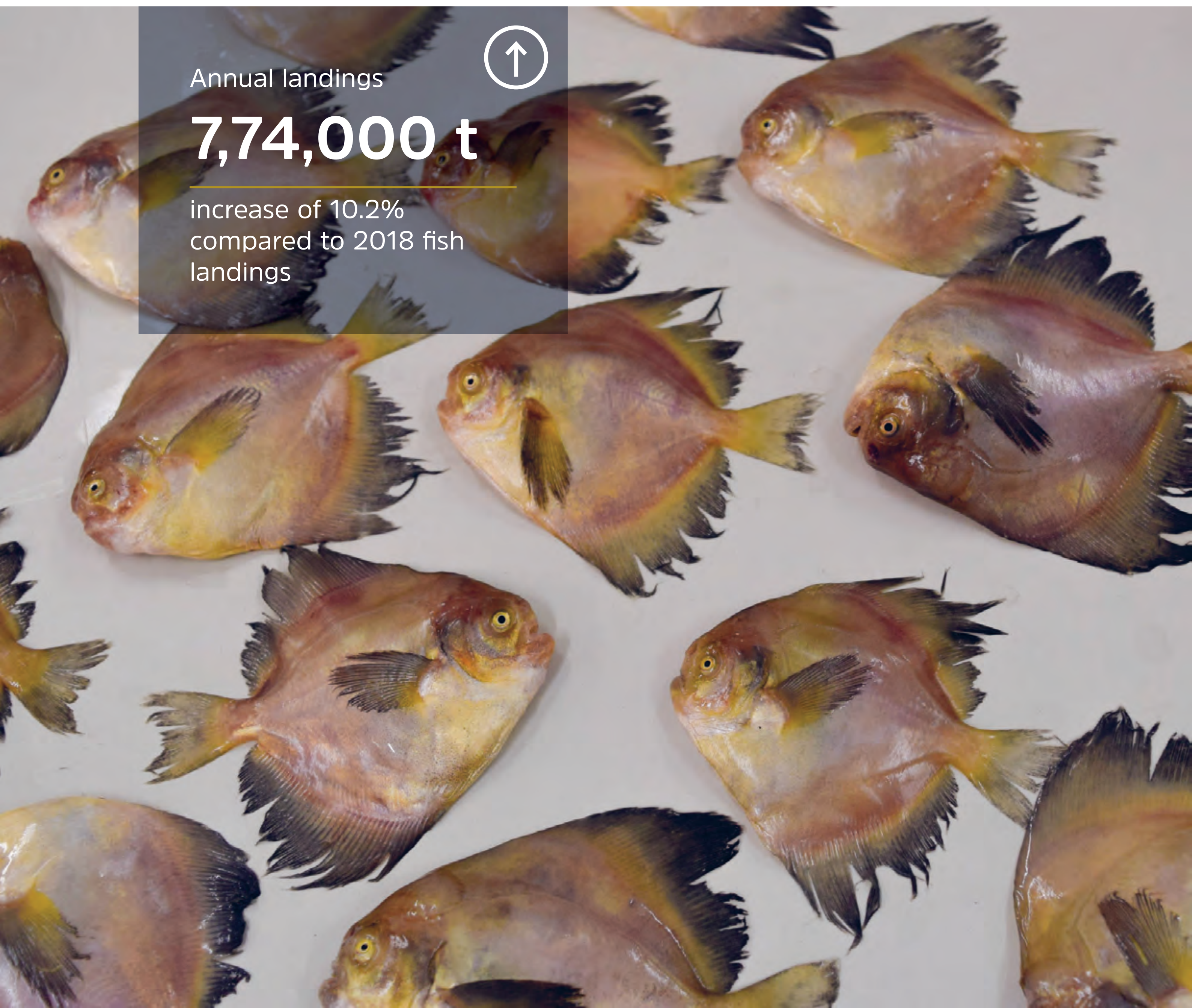
Tamil Nadu and Puducherry

Research Project PEL/RMS/08

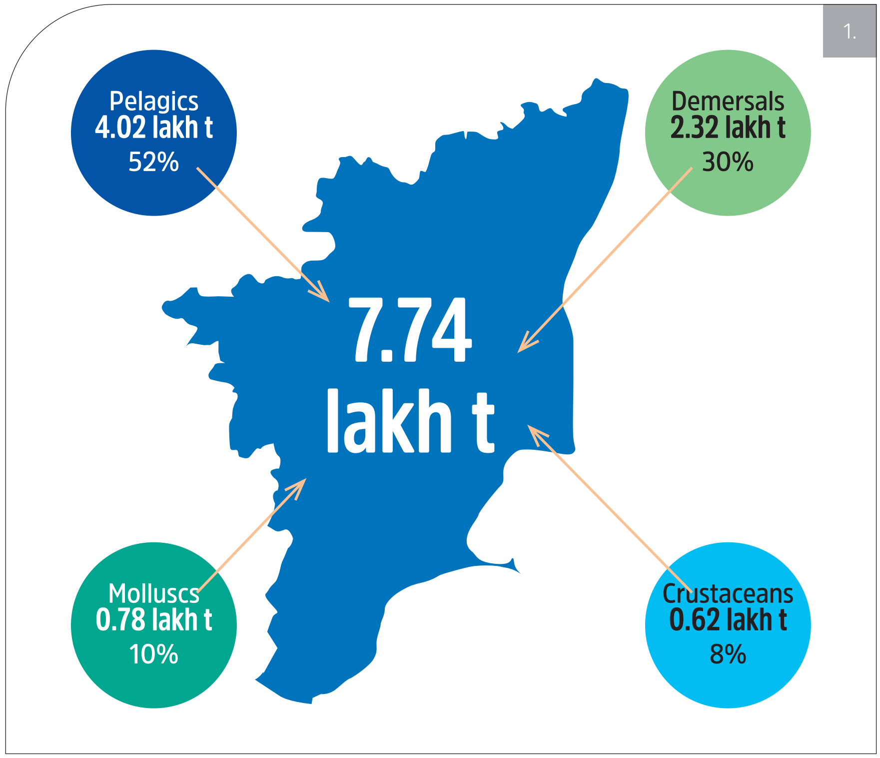
Annual landings

7,74,000 t

increase of 10.2% compared to 2018 fish landings



Juvenile pomfrets landed in Chennai



Tamil Nadu

The total marine fish landing in Tamil Nadu in 2019 was 7.74 lakh t, increasing by 10.2% from 2018. Among the 13 coastal districts, maximum contribution was from Ramanathapuram (27.3%) followed by Kanyakumari (18.1%), Nagapattinam (12.1%), Chennai (10.7%), Pudukottai (8%), Tuticorin (7.9%) and Cuddalore (7.7%). The remaining six districts together contributed 8.2%.

Mechanized trawl was the dominant gear with single day mechanized trawls contributing 51.8% of the total landing followed by multiday trawlers (18.1%). Other major contribution was from motorized (outboard) gillnet (10%). Multiday trawl net with hook & line and mechanized gill net contributed 8.3 and 4.5% respectively. Other gears contributed 7.3% of the total catch. The catch-per-hour in single day and multi day trawler was 111 and 85.6 kg/h respectively. The catch rate in out board and mechanized gillnet was 71 and 6463 kg/unit respectively.

Pelagic finfishes formed 52%, demersal finfishes 30%, crustaceans 8% and molluscs 10%. Major pelagic resources landed were clupeids, mackerel, carangids, ribbonfishes, tunas, barracudas, seerfishes and billfishes. Major demersal resources were silverbellies, perches, lizardfishes, elasmobranchs, goatfishes, croakers, mullets, catfishes and pomfrets. Penaeid shrimps and crabs constituted >98% of the crustacean landings, with non-penaeid shrimps, lobsters and stomatopods accounting for a minor share. Major molluscan resources were cephalopods, gastropods and bivalves.

Commercially important fishery resources that contributed significantly were lesser sardines (10.0%), silver bellies (10.9%), oil sardine (8.2%), other carangids (7.1%), cephalopods (6.8%), other perches (4.1%), penaeid shrimps (3.2%) and crabs (3.0%). Compared to 2018, seer fishes, anchovies, other clupeids, tunas, goatfishes, ribbonfishes and croakers increased in the landings while mackerel, lesser sardines, elasmobranchs, crabs and threadfin breams showed a decline.

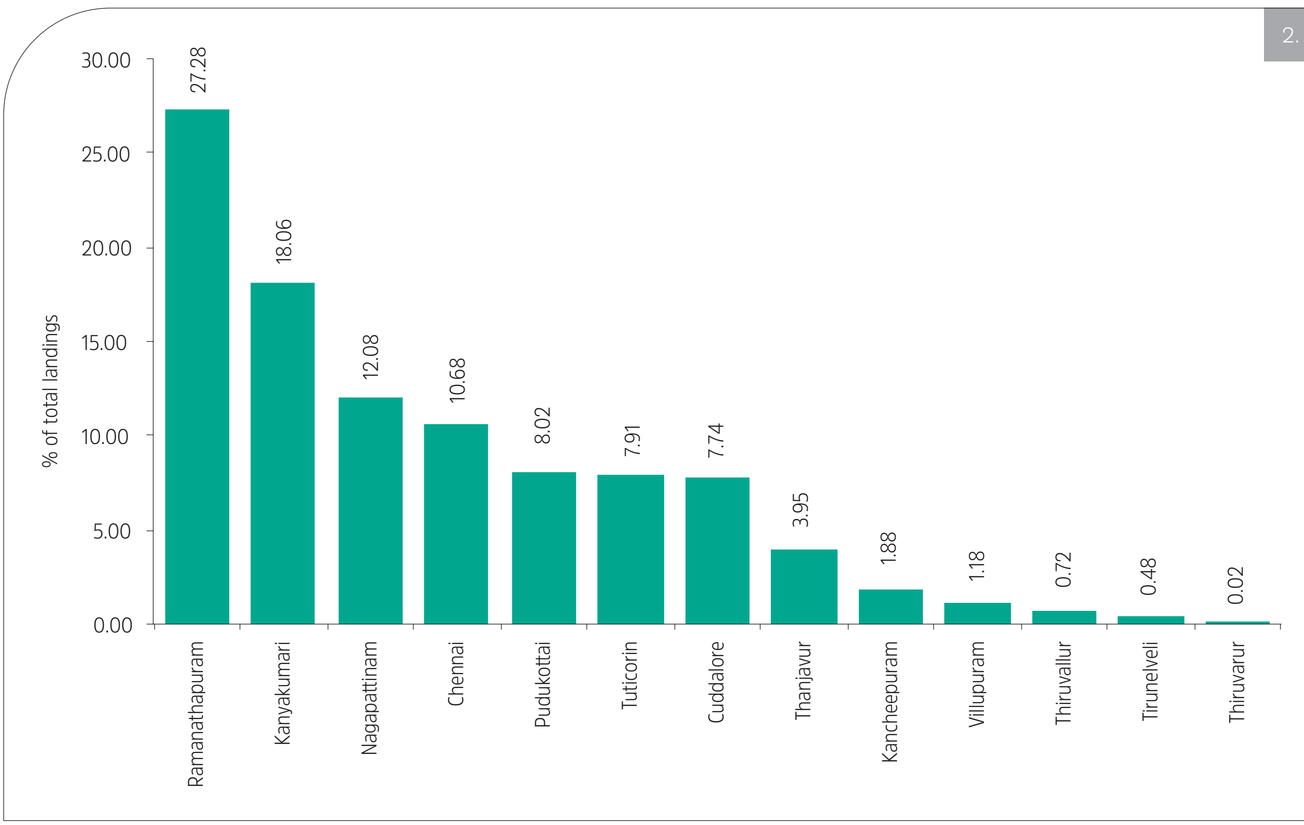
Pelagic fishes

Sardines: Total sardine landings in Tamil Nadu was 140630 t of which oil sardine *Sardinella longiceps* accounted for 45% (63413 t) and lesser sardines accounted for 55% (77218 t). The oil sardine landings in 2019 increased by 57.4% from 2018. Mechanised trawl nets landed 61.3%, motorized gill nets landed 16.9% while other gears (including ring seines) accounted for 21.8%. The CPUE was highest in mechanized ring seines being 2249 kg while in motorized ring seine it was 590 kg.

Lesser sardine landings in Tamil Nadu decreased by 17.5% compared to 2018. The resource was mainly landed by mechanized trawl nets contributing (75.7%) and motorized gill nets (12.7%).

1. Share of resource groups in total marine landings in Tamil Nadu in 2019
2. District-wise contribution to marine fish landings in Tamil Nadu in 2019
3. Sector-wise contribution to marine fish landings in Tamil Nadu in 2019

2.



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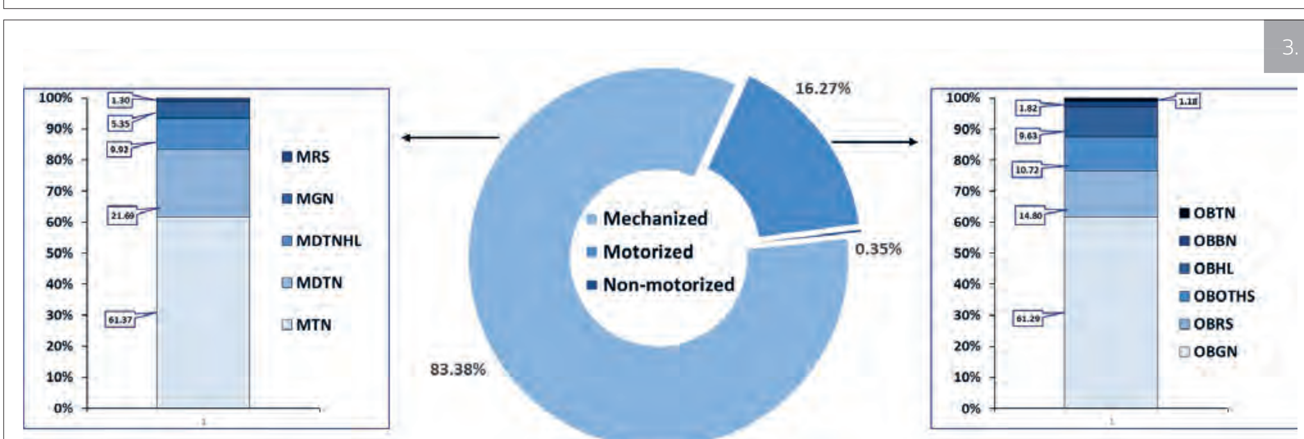


Mackerel: Mackerel landing in 2019 was 24114 t, decreasing by (31.5%) from 2018. Mechanized trawl nets landed 45.3%, motorized gill nets, 28.1% and motorized ring seines, 8.3%. Two species, *Rastrelliger kanagurta* and *Rastrelliger faughni* constituted the mackerel landings.

Carangids: Carangid landing during the year was 73142 t, decreasing by 58%. They contributed 18.9% to the total pelagic fish landings of Tamil Nadu. Mechanized single-day trawls landed 51.8% of the total carangid resource catch), followed by multi-day trawls (20.8%), multi-day trawl and hook & line combination (13.2%) and motorized gill nets OBGN (5.7%). Scads contributed 18%, horse mackerel (4.3%), leather jackets (2.5%) and other carangids contributed (75%) of the carangid landings.

Ribbonfishes: Ribbonfish landing in 2019 was 13894 t, increasing by 27.8% from 2018. Maximum landing was by multi-day trawls (50.9%), followed by single day trawls (28.6%), multi-day trawl and hook & line combination (15.06%), and motorized gill nets (4.02%).

Seerfishes: Seerfish landing increased from 7299 t in 2018 to 13018 t in 2019 They were exploited mainly by single-day trawls (40.1%), multi-day trawl and hook and line combination (20.5%), motorized gill nets (17.6%), multi-day trawls (10.6%) and hook and lines (5.9%) . The fishery was supported by four species and *S. commersoni* contributed maximum (81.6%) followed by *S. guttatus* (15.4%), *Acanthocybium solandri* (2.8%) and *S. lineolatus* (0.01%).

Tunas: The landing of tunas in 2019 was 39028 t, increasing by 32.6% from 2018. Tunas were mainly exploited by mechanized gill nets (55.0%), mechanized and motorized ring seines (23.1%), multi-day trawl and hook & line combination (9.0%) and motorized gill nets (7.0%). The skipjack tuna *Katsuwonis pelamis* was the dominant species (50%) followed by *Euthynnus affinis* (20.9%) and *Auxis* spp. (13.1%).

Barracudas: Total landing of barracudas in Tamil Nadu during the year was 13723 t, 65.8% of which was landed by mechanized single day trawls, 14.4% by multiday trawls, 9.1% by multi-day trawl and hook & line combination and 6% by motorized gillnets.

Demersal fishes

Silverbellies: The total landing of silverbellies in Tamil Nadu was 84044 t, an increase by 30.8% from

Major resources in the landings (>1% in resource group)

Resource group	Resource	% in resource group
PELAGIC FISHES	Lesser sardines	19.3
	Carangids	18.2
	Oil sardine	15.8
	Tunas	11.6
	Mackerels	6.0
	Anchovies	5.0
	Other clupeids	4.3
	Ribbonfishes	3.5
	Barracudas	3.4
	Seerfishes	3.2
	Billfishes	1.3
DEMERSAL FISHES	Silver bellies	35.6
	Perches	15.6
	Lizard fish	8.0
	Elasmobranchs	6.4
	Goat fish	5.6
	Croakers	4.8
	Mullets	4.1
	Catfishes	2.1
	Pomfret	1.4
CRUSTACEANS	Penaeid shrimps	49.9
	Crabs	48.2
MOLLUSCS	Squids	49.5
	Cuttlefishes	32.5
	Octopus	7.2
	Gastropods	6.6
	Bivalves	4.2

Length range and mean length of major pelagic fishes in the fishery

Species	Region	Length range (mm)	Mean length (mm)
Rastrelliger kanagurta	Chennai	110-300	211.3
	Mandapam	102-290	203.7
Rastrelliger faughni	Chennai	70-290	156.4
Selaroides leptolepis	Mandapam	87-200	141.2
Stolephorous indicus	Mandapam	64-149	117.1
Sphyraena jello	Chennai	190-270	231
	Mandapam	419-2500	935.5
Sphyraena putnamae	Chennai	277-790	471
Sphyraena obtusata	Chennai	200-290	241
Sphyraena forsteri	Chennai	180-260	225
Scomberomorous commerson	Chennai	70-810	215
	Mandapam	108-1400	491.5
Caranx ignobilis	Mandapam	340-1190	766
Caranx heberi	Mandapam	105-565	287.3
Stolephorous indicus	Mandapam	67-140	107
Rachycentron canadum	Chennai	310-670	434
	Mandapam	105-1510	738.2
Elops machanata	Mandapam	120-2500	938.5
Gnathonodon speciosus	Mandapam	90-1550	342.3
Trachinotus blochi	Mandapam	241-1010	589.3
Alectis indica	Mandapam	121-1080	420.3
Chirocentrus dorab	Mandapam	240-1040	467.8
Trichurus lepturus	Mandapam	150-900	587.8
Ablennes hians	Mandapam	200-960	659
Tylosorous crocodilus	Mandapam	220-1200	777
Sardinella gibbosa	Mandapam	85-199	123
Sardinella albella	Mandapam	80-151	118
Hemiramphus far	Mandapam	200-395	264

2018. Mechanized single-day trawls landed nearly 86% of the total landing, followed by MDTN (8.2%). Twelve species of silverbellies were dominant in the fishery–*Eubleekeria splendens, Eubleekeria jonesi, Equulites lineolatus, Gazza minuta, Karalla dussumieri, Leiognathus brevirostris, Leiognathus daura, Leiognathus equulus, Nuchequulus gerreoides, Photopectoralis bindus, Secutor insidiator* and *Secutor ruconius.*

Goatfishes: An estimated total of 13289 t of goatfishes were landed during the year 2019 an increase of 30.7% from 2018. Mechanized single day trawls accounted for 62.2%, followed by multiday trawls (23.4%), motorized gillnets (7.7%) and multi-day trawl and hook and line combination (5.4%). The fishery was dominated by *Parupeneus indicus, Parupeneus heptacanthus, Upeneus sulphureus, Upeneus tragula, Upeneus vittatus Upeneus margarethae, Upeneus moluccensis, Upeneus sundaicus, Upeneus sulphureus, Upeneus tragula* and *Upeneus taeniopterus.*

Threadfin breams: An estimated total of 16740 t of threadfin breams were landed showing a decline of 6.6% from 2018. Multiday trawls contributed 44.1%, followed by single day trawls (28.6%), multi-day trawl and hook & line combination (20.5%), and motorized gill nets (5.53%). The major species that contributed to the

1. Tuna landings at Tharuvaikulam, Tuticorin

landings were *Nemipterus bipunctatus, Nemipterus japonicus, Nemipterus randalli, Nemipterus peronii, Nemipterus nematophorus, Scolopsis bimaculatus, Scolopsis vosmeri,* and *Parascolopsis erioma.*

Pigface breams: The total landing of pigface breams was 10464 t, 33.9% of which was landed by mechanized single day trawls, 24.8% by motorized hook & line, 23.1% by motorized gill nets, 10.4% by multiday trawls and 6.6% by multi-day trawl and hook & line combination. The species that contributed to the fishery were *Lethrinus lentjan, Lethrinus nebulosus, Lethrinus obsoletus, Lethrinus microdon, Lethrinus harak, Lethrinus mahsena*, *Lethrinus miniatus* and *Lethrinus ornatus*

Rock cods: About 2474 t of rock cods were landed in Tamil Nadu in 2019. Hook & lines units landed 24.3%, followed by multiday trawls (22.2%), multi-day trawl and hook & line combination (20.7%), mechanized single day trawls (14.9%) and motorized gill nets (12.7%). The fishery was supported by *Epinephelus malabaricus, Epinephelus longispinis, Epinephelus bleekeri, Epinephelus undulous, Epinephelus areolatus, Epinephelus fasciatus, Epinephelus chlorostigma, Epinephelus radiatus, Epinephelus longispinis, Epinephelus merra, Epinephelus tauvina, Cephalopholis sonnerati* and *Cephalopholis formosa.*

Snappers: An estimated total of 5133 t of snappers were landed during the year 2019. Mechanized single day trawls contributed 26.9%, multiday trawls 25.2%, motorized hook & line 23.3%, motorized gill nets 12% and multi-day trawl and hook & line combination 8.8%. Snappers were represented in the fishery by *Lutjanus lutjanus*, *Lutjanus fulvus*, *Lutjanus argentimaculatus*, *Lutjanus quinquilineatus*, *Lutjanus rivulatu*, *Lutjanus johnii*, *Lutjanus ehrenbergii*, *Lutjanus fulviflamma*, *Lutjanus bohar, Pristipomoides filamentosus* and *Pinjalo pinjalo* (3.9%).

Croakers: An estimated total of 11252 t of croakers was landed in Tamil Nadu during the current period showing an increase of 8.8% from the previous year. Mechanized single day trawls contributed 56.1%, followed by multiday trawls (21.5%), motorized gill nets (5.5%), motorized hook & line (11.1%) and multi-day trawl and hook & line combination (6.4%). The dominant species in the landings were *Nibea maculata*, *Johnius carutta, Johnius dussumieri*, *Kathala axillaris*, *Otolithes ruber, Johnius sina*, *Johnius belangerii*, *Pennahia anea* and *Protonibea diacanthus*.

Pomfrets: Landing of pomfrets in 2019 was 4084 t, forming 1.8% of the demersal fish landings. Mechanized

Length range and mean length of major demersal fishes in the fishery

Species	Region	Length range (mm)	Mean length (mm)
Nemipterus japonicus	Chennai	90- 259	147
Nemipterus randalli	Chennai	80-179	131
Nemipterus bipunctatus	Tuticorin	159-297	223.4
Upeneus guttatus	Chennai	90-159	122
Upeneus sulphureus	Chennai	100-169	118
Upeneus sulphureus	Mandapam	131-140	135.2
Upeneus sundaicus	Mandapam	138-156	145.1
Upeneus tragula	Mandapam	134-156	145.1
Parupeneus indicus	Mandapam	172-189	178.7
Parupeneus indicus	Tuticorin	123-338	215.3
Otolithes ruber	Chennai	140-329	219
Nibea maculata	Chennai	80-229	138
Nibea maculata	Mandapam	146-183	153.1
Dendrophysa russelii	Mandapam	143-153	146.9
Pennahea anea	Mandapam	150-163	157.5
Otolithes ruber	Mandapam	187-202	191.6
Eubleekeria jonesi	Mandapam	96-102	101.5
Nuchequulus gerreoides	Mandapam	98-109	105.3
Equulites lineolatus	Tuticorin	76-130	99.4
Karalla daura	Mandapam	110-123	116.3
Karalla dussumieri	Mandapam	111-129	119.6
Gazza minuta	Mandapam	112-117	114.5
Gazza minuta	Tuticorin	65-150	96.1
Parastromateus niger	Chennai	80-339	190
Psettodes erumei	Chennai	150-599	337
Saurida micropectoralis	Chennai	100-359	222
Epinephelus malabaricus	Tuticorin	180-810	380
Osteogenosis militaris	Mandapam	274-308	290
Lethrinus lentjan	Tuticorin	141-381	250.6

single day trawls landed 63.5%, followed by multiday trawls (20.1%), multi-day trawl and hook & line combination (7.3%), mechanized ring seines (4.8%), and motorized gill nets (3.9%). *Pampus argenteus* formed 70% of the pomfret landings *Parastromateus niger*, 27% and *Pampus chinensis*, 3%.

Lizardfish: Total landing of lizardfishes was 18583 t, 45% of which was landed by single day trawls, 33.3% by multiday trawls, 18.1% by multi-day trawl and hook & line combination and 3.7% by motorized gill net. At Chennai, lizardfishes formed 10.2% of the demersal fish landings, and were comprised of *Saurida micropectoralis* (53.7%), *S. undosquamis* (31.3%), *S. tumbil* (9.2%), *Trachinocephalus myops* (5.5%) and *S. longimanus* (0.3%).

Elasmobranchs: Elasmobranch landing during 2019 was 12175 t which was 14.1% less than the landing in 2018. The mechanized sector contributed to more than 68% of the elasmobranch landings, while the motorized sector contributed 31%. The non-motorized sector contributed less than 1%. Gill nets, trawl nets and line gear were the major gears, contributing 46, 43 and 10% of the total elasmobranch landing. The catch per unit of elasmobranchs in mechanized trawl net, mechanized line gear and mechanized gillnet was 18, 93 and 371 kg respectively. Rays formed 81.3 sharks 11.5% and guitarfishes 7.2% of the landed elasmobranchs. While the landings of sharks and guitarfishes fell by 71 and 27% respectively, from 2018, the landings of rays increased by 25%.

Crustaceans

Shrimps: The total penaeid shrimp catch of Tamil Nadu during 2019 was 24399 t. Mechanized single day trawls landed 50.1%, multiday trawls, 25.5%, multiday trawl and hook & line combination units, 19.6% and motorized trawls, 3.2%. The total landing of non-penaeids was 433 t. Fifteen species contributed to the penaeid shrimp fishery in Palk Bay

1. Gill net landing of pelagic fishes at Tharuvaikulam, Tuticorin

Size range and mean size of shrimps landed at Chennai

Species	Size range (mm)	Mean size (mm)
Penaeus semisulcatus	71-235	146
Penaeus monodon	116-280	233
Penaeus penicillatus	116-155	133
Penaeus merguiensis	126-200	162
Penaeus canaliculatus	141-165	152
Penaeus indicus	76-260	129
Penaeus japonicus	111-235	157
Metapeaeopsis andamanensis	56-110	79
Metapeaeopsis hilarula	61-85	73
Metapeaeopsis gallensis	56-105	73
Metapeaeopsis mogiensis	51-100	71
Metapeaeopsis.stridulans	51-105	85
Metapeaeopsis toloensis	56-110	83
Metapenaeus dobsoni	51-125	87
Metapenaeus moyebi	51-110	78
Metapenaeus alcocki	61-75	70
Metapenaeus affinis	76-190	131
Metapenaeus monoceros	51-200	128
Metapenaeus.ensis	96-190	140
Metapenaeus krishnatrii	81-95	89
Trachysaambria curvirostris	56-110	78
Trachysalambria aspera	51-105	78
Megokris sedili	46-95	78
Megokris granulosus	41-105	80
Solenocera crassicornis	66-110	91
Solenocera koelbeli	71-110	88
Solenocera choprai	51-120	82
Solenocera hextii	61-100	86
Parapenaeus longipes	61-90	77
Parapenaeus fissurus	81-100	88
Parapenaeopsis stylifera	61-130	99
Parapenaeopsis uncta	66-145	100
Parapenaeopsis hardwickii	121-125	123
Parapenaeopsis maxillipedo	51-110	81
Parapenaeopsis acclivirostris	46-65	57
Parapenaeopsis cornuta	56-65	61
Aristeus alcocki	66-140	96
Heterocarpus gibbosus	91-110	101
Glyphocrangon investigatoris	81-100	90
Sicyonia sp.	41-70	55
Nematopalaemon tenuispines	61-65	63

by mechanized trawls; *Penaeus semisulcatus* (58%), *Parapenaeopsis maxillipedo* (10%) and *Metapenaeus lysianassa* (7%) were the major contributors. Fourteen species contributed to the fishery in the Gulf of Mannar; *Penaeus semisulcatus* (57%), *Metapenaeopsis stridulans* (12%) and *Parapenaeopsis maxillipedo* (9%) were the major contributors. At Chennai, the penaeid shrimp landings comprised of 41 species. *Metapenaeus* spp. dominated forming 49% followed by *Metapenaeopsis* spp. forming 20%. In Kanyakumari, *Parapenaeopsis* spp. formed the major catch (56.9%), followed by *Metapenaeopsis toloensis*, *Parapenaeus* spp., *Solenocera crassicornis*, *Penaeus monodon* and *Penaeus semisulcatus*.

Crabs: The landing of marine crabs in Tamil Nadu in 2019 was 23566 t. Of this, 39.7% of the catch accounted for mechanized single day trawls, 37.5% by motorized gillnets, 12.8% by multiday trawls and 5.4% by the non-motorized sector. *Portunus pelagicus* was the dominant species in Palk Bay, contributing to 72% of the crab landing, followed by *Portunus sanguinolentus* (25%) *Charybdis natator* (3%) and *Charybdis feriatus* (0.01%).

Size range and mean size of lobsters

Species	Region	Sex	Size range (mm)	Mean size (mm)
Thenus unimaculatus	Chennai		76-210	146
	Mandapam	M	120-290	183.59
		F	100-224	156.78
Panulirus ornatus	Chennai		95-265	
	Mandapam	M	150-385	225.45
		F	150-380	234.11
Panulirus versicolor	Chennai		206-210	
	Mandapam	M	210-290	256.67
		F	220-340	270
Panulirus homarus	Chennai		31-215	128
	Mandapam	M	100-160	127.9
		F	95-165	132
Panulirus penicillatus	Chennai		216-220	
Panulirus polyphagus	Chennai		131-135	
Nephropsis stewartii	Chennai		56-125	97
Palinustus waguensis	Chennai		116-135	123

Size range and mean size of crabs

Species	Region	Sex	Size range (CW, mm)	Mean size (CW,mm)
Portunus pelagicus	Chennai		56-170	84
	Palk Bay	M	70-250	149.6
		F	20-220	156.7
Charybdis natator	Chennai		46-95	64
	Palk Bay	M	54-125	91.1
		F	55-179	87.5
Portunus sanguinolentus	Chennai		51-165	100
	Gulf of Mannar	M	25-149	120.7
		F	20-155	121.3
Portunus gladiator	Chennai		41-95	71
Podophthalmus vigil	Chennai		51-205	93
Charybdis feriatus	Chennai		81-120	98
Charybdis lucifera	Chennai		41-105	66
Charybdis riversandersoni	Chennai		56-80	68
Charybdis granulata	Chennai		31-100	55
Charybdis natator	Chennai		46-95	64
Charybdis hoplites	Chennai		66-70	68
Charybdis smithii	Chennai		31-75	60
Galene bispinosa	Chennai		46-80	61
Thalamita crenata	Chennai		66-70	68

Portunus sanguinolentus dominated the fishery in the Gulf of Mannar, contributing 48% of the landing, followed by *P. pelagicus* (28%), *C. natator* (22%) and *P. gladiator* (2%). In Kanyakumari, four species constituted the fishery–*P. sanguinolentus* (59.5%) followed by *C. natator* (37.2%), *P. pelagicus* (3.1%) and *C. lucifera* (0.2%). Crab landings at Chennai consisted of 14 species. *Portunus* spp. dominated, forming 61%, followed by *Charybdis* spp. forming 31%.

Lobsters: The total landings of lobsters in Tamil Nadu was estimated as 429 t. Multiday trawl nets landed the bulk of the catch, followed by single day trawl net and outboard gillnets. *Panulirus ornatus* and *Panulirus homarus* were the dominant species in the Gulf of Mannar fishery. In Kanyakumari, multi day trawlers accounted for 67.4% of the lobsters, single day trawlers, 24.1% and

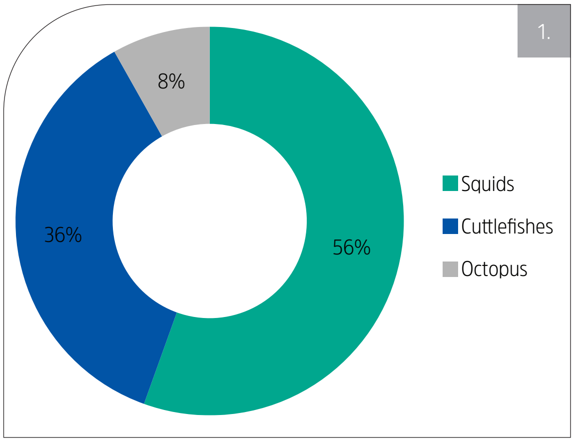
Species composition of cephalopod species in trawl landings

1. Composition of cephalopod landings in Tamil Nadu in 2019

Cuttlefish	Tuticorin	Chennai
Sepia pharaonis	45	40
S. ramani	37	
S. prabahari	17	
S. aculeata		16
S. brevimana		23
S. prashadi	1	12
Sepiella inermis		9
Squids		
Uroteuthis (Photololigo) duvauceli	22	51
U. (Photololigo) singhalensis	35	44
Loligo uyii		2
Sepiotuethis lessoniana	43	3
Octopus		
Amphioctopus marginatus	37	
Amphioctopus neglectus	2	
Octopus cyanea	61	
O. dollfusi		39
Octopus membranaceus		33
Cistopus indicus		28

Size range, mean size and sex ratio of cephalopods in trawl landings

Species	Region	DML (mm)	Mean (mm)	Sex ratio
Sepia pharaonis	Chennai	40-165	88	**1:**0.6
	Tuticorin	70-400	235	**1:**0.9
S. aculeata	Chennai	60-115	85	**1:**0.59
S. brevimana	Chennai	30-95	61	**1:**0.88
S. prashadi	Chennai	47-115	90	**1:**0.85
S. ramani	Tuticorin	99-380	232	**1:**0.7
S. prabahari	Tuticorin	50-137	89	**1:**0.84
Sepiella inermis	Chennai	40-96	62	**1:**0.80
Uroteuthis (Photololigo) duvauceli	Chennai	27-156	78	**1:**0.22
	Tuticorin	67-315	127	**1:**1.2
Uroteuthis (Photololigo) singhalensis	Chennai	70-225	119	**1:**0.62
	Tuticorin	36-295	122	**1:**0.7
Sepiotuethis lessoniana	Tuticorin	75-313	154	**1:**0.8
Amphioctopus marginatus	Tuticorin	38-200	81	**1:**0.6
A. neglectus	Tuticorin	20-119	63	**1:**0.8
Octopus dollfusi (TI)	Chennai	170-420	260	**1:**0.12
O. membranceus (TL)	Chennai	120-310	208	**1:**0.13
O. cyanea	Tuticorin	80-260	160	**1:**0.7



Size at first maturity of cephalopods landed at Chennai

Species	L_{m50} (mm)
Uroteuthis (Photololigo) duvaucelii	80
Uroteuthis (Photololigo) singhalensis	90
Sepia pharaonis	90
Sepia aculeata	80
Sepia brevimana	70
Sepiella inermis	65
Sepia prashadi	75
Octopus dollfusi (Tl)	165
Octopus membranceus (TL)	160

Stock indices of cephalopods

Species	Region	L_∞ (mm)	K (y^{-1})	M	F	Z	E
Sepia prabahari	Tuticorin	158	1.5	2.13	2.58	4.71	0.55
Sepia pharaonis	Tuticorin	481	1.5	1.7	3.3	5.0	0.66
Uroteuthis (Photololigo) duvauceli	Chennai	320	0.85	1.62	1.62	4.52	0.63
Sepiella inermis	Chennai	122.5	2.25	4.01	4.73	8.74	0.54

motorized gill nets, 8%. *P. homarus*, *P. ornatus*, *Panulirus versicolor*, *Thenus unimaculatus* and the deepsea lobster *Puerulus sewelli* were the constituent species. The lobster fishery in Chennai was comprised by 8 species, with *T. unimaculatus* dominating the landings.

Cephalopods: The total estimated cephalopod landing of Tamil Nadu for the year 2019 was 52840 t. Squids, cuttlefishes and octopus constituted the fishery in same order of dominance.

Multiday trawls accounted for 38% of the cephalopod landings, single day trawls, 34% multiday trawl and hook and line combination, 22%, motorized gillnets, 3% and motorized hook and line, 1%.

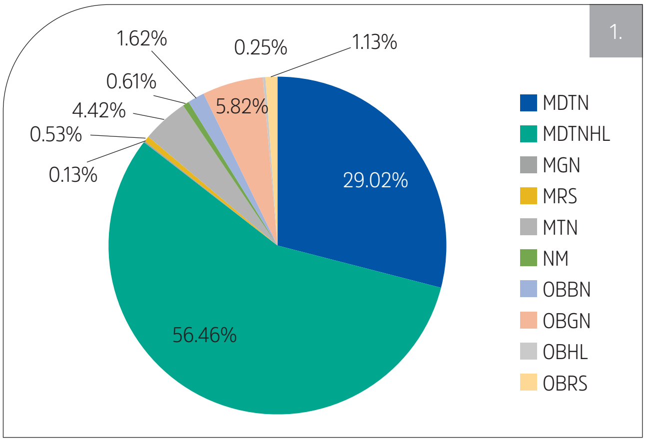
Puducherry

Total trawl landings at Puducherry (including Karaikkal) was about 36871.7 t, decreasing by about 10.1% from the previous year. The mechanized sector contributed 90.6% of the total landings, in which multiday trawl and hook & line combination units contributed 56.5%, multiday trawls, 29% and mechanized single day trawls, 4.4%. Motorized sector contributed 8.8% and non-motorized sector, 0.6%. Puducherry contributed 61% of the total landing and Karaikal District contributed 39%. Catch rate was 62.6 kg/h for trawl, 18.8 kg/unit for gillnet, 99.7 kg/unit for hook and line, 1135 kg/unit for ring seine and 22 kg/unit for non-motorized operations.

Pelagic finfishes with an annual landing of 12624 t formed 34% of the total marine fish landings in Puducherry during 2019. The major resources landed were carangids, seerfishes, sardines, anchovies, mackerels, barracudas, other clupeids and tunas. The estimated catch of demersal fishes was 9526 t, forming 25.8% of the total landings. The major resources were silverbellies, pomfret, threadfin breams, other perches, lizardfishes, croakers, and elasmobranchs. The total estimated crustacean landing was 5351 t which formed 14.1% of the total. Penaeid shrimps, crabs and lobsters were the major resources landed. Molluscan landings were to the tune of 9369 t, forming 25.4% of the total landings. Squids, cuttlefishes, octopus and gastropods contributed to the fishery.

Economic performance of fishing methods

The economic performance of various fishing methods in selected centres in Tamil Nadu and Puducherry was assessed using major economic indicators namely net operating income, operating ratio (Capital productivity), labour productivity,



1. Sector-wise contribution to marine fish landings in Puducherry (including Karaikkal) in 2019

2. Landings of pelagic fishes at Therkuvadi fish landing centre, Pamban

3. Landed catch at Madras Fisheries Harbour, Chennai

Major resources in the landings (>1% in resource group)

Resource group	Resource	% in resource group
PELAGIC FISHES	Carangids	38.7
	Seerfishes	13.1
	Sardines	11.6
	Ribbonfishes	10.5
	Anchovies	10.2
	Mackerels	5.6
	Barracudas	3.8
	Other clupeids	3.0
	Tunas	1.3
DEMERSAL FISHES	Silver bellies	16.9
	Pomfrets	15.3
	Threadfin breams	13.3
	Other perches	12.9
	Lizardfishes	9.6
	Croakers	8.1
	Elasmobranchs	7.9
	Goatfishes	3.8
	Flatfishes	3.0
	Rock cods	2.7
	Snappers	2.4
	Catfishes	1.5
	Mullets	1.0
	Pigface breams	1.0
CRUSTACEANS	Penaeid shrimps	64.6
	Crabs	31.9
	Lobsters	1.9
MOLLUSCS	Squids	58.6
	Cuttlefishes	32.2
	Octopus	5.6
	Gastropods	2.2

input-output ratio and gross value. Capital productivity sector was most efficient in multiday-day gill net at Chennai (among mechanized units) with the lowest operating ratio of 0.46 followed by single day fish trawl at Ramanathapuram (0.55) and mechanized trawl of SDF (0.57). Overall, the capital productivity was very much efficient in the case of non-mechanized bottom set gillnet (0.42), to the lower proportion of crew wages as most of the non-mechanized units are operated by family labour only.

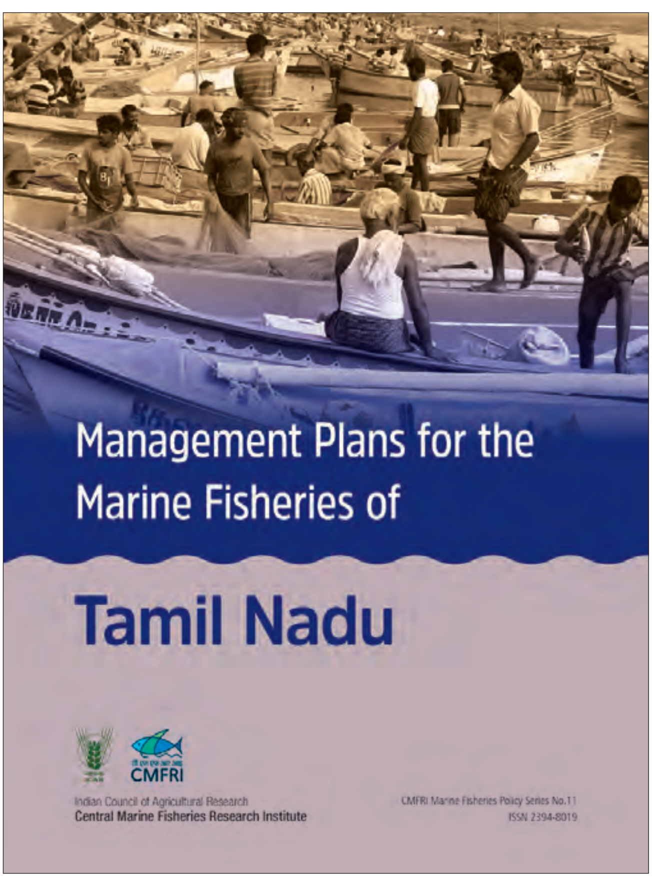
Monthly capital productivity of mechanized single day trawling for shrimp and fish resources in Ramanathapuram District varied from 0.57 to 0.72 and 0.42 to 0.67 respectively. The economic performance of mechanized single day trawling for shrimp and fish resources was relatively better in June (0.35) and April (0.42) respectively. The average operating cost of motorized multi-day gill net fishing in Ramanathapuram district was 24,867 per unit with an average gross return of 39,160. The average capital productivity ratio was 0.64. Average operating cost of motorized single day bottom set gill net and other bottom set gill net fishing was 1,346 and 1,606 per unit with average gross return of 2,328 and 2,774 respectively. Average capital


2.


3.

Economic performance of fishing methods in Tamil Nadu

Centre	Craft-gear combinations	Operating Ratio
Ramanathapuram	Single day shrimp trawl	0.65
	Single day fish trawl	0.55
	Motorized Multi-day gill net	0.64
	Non-mechanized bottom set gill net	0.42
Chennai	Multi-day trawling (4-5days)	0.67
	Multi-day gill net (2-5 days)	0.46
Thuthoor	Multi-day trawling	0.78
	Motorized gill net	0.75
	Non-mechanized gill net	0.68
Thengapattinam	Motorized	0.78
	Non-motorized	0.63
Colachel	Mechanized single-day trawl	0.57
Muttom	Mechanized multi-day trawl	0.64
	Mechanized gill net	0.62
	Motorized gillnet	0.78
	Non-motorized gill net	0.63



productivity ratio was 0.58 for both gears. The average operating cost of non-mechanized bottom set gill net and other bottom set gill net fishing in the district was 235 and 210 per unit with average gross return of 555 and 479 respectively. Average capital productivity ratio was 0.42 and 0.44 respectively.

Recommendations for management plans for the marine fisheries of Tamil Nadu

A policy document titled "Management Plans for the Marine Fisheries of Tamil Nadu" was published in 2019. It presents an overall picture of the present status and trends in marine fisheries sector of the state and puts forth recommendations based on scientific studies and interactions with stakeholders, to evolve suitable management measures for sustainable fisheries.

Andhra Pradesh

Research Project DEM/RMS/10

Yellowfin tuna being offloaded at Visakhapatnam

Annual catch

2,59,029 t

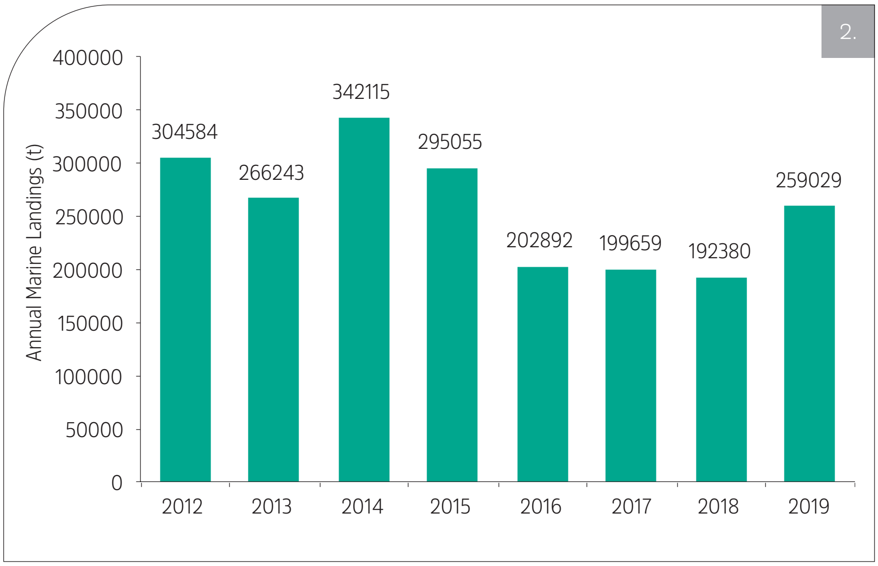
increase of 35% landings compared to 2018

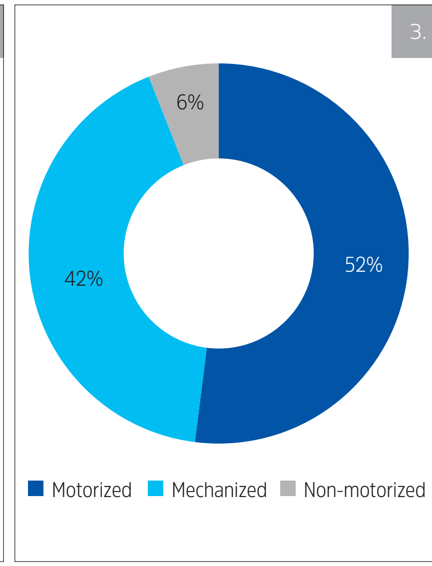

1.

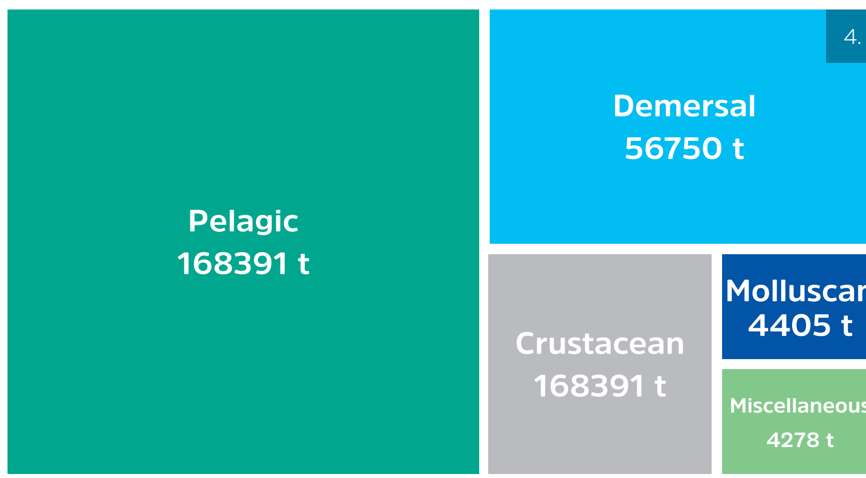
The total marine landing of Andhra Pradesh during 2019 was 259029 t. Total landings showed an increase of 35% from the previous year, reversing the declining trend in landings seen in the state from 2014 onwards. Unlike previous years, the motorized sector was the highest contributor to marine landings of the state (52%), followed by the mechanized sector (42%) and the non-motorized sector (6%).

Major marine resource groups landed

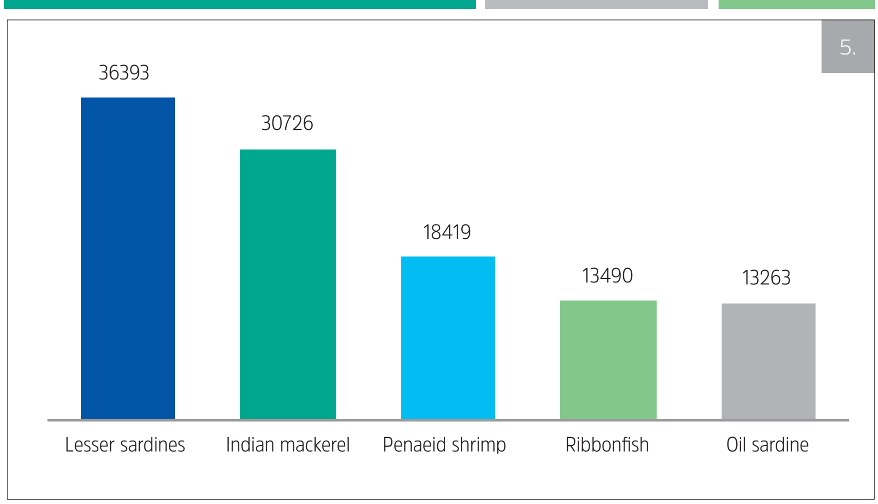
Marine landings of Andhra Pradesh in 2019 were dominated by pelagic resources (65%), followed by demersal resources (21.9%), crustacean resources (9.7%) and molluscan resources (1.7%). Miscellaneous groups formed 1.7% of the annual marine landings of Andhra Pradesh. The top five resources in terms of quantity were lesser sardines, Indian mackerel, penaeid shrimp, ribbonfish and Indian oil sardine. Most marine resources showed an increase from 2018 levels with Indian oil sardine, rays, guitarfish, *Auxis* spp., lesser shads and non-penaeid shrimp showing more than two times increase from 2018 levels.



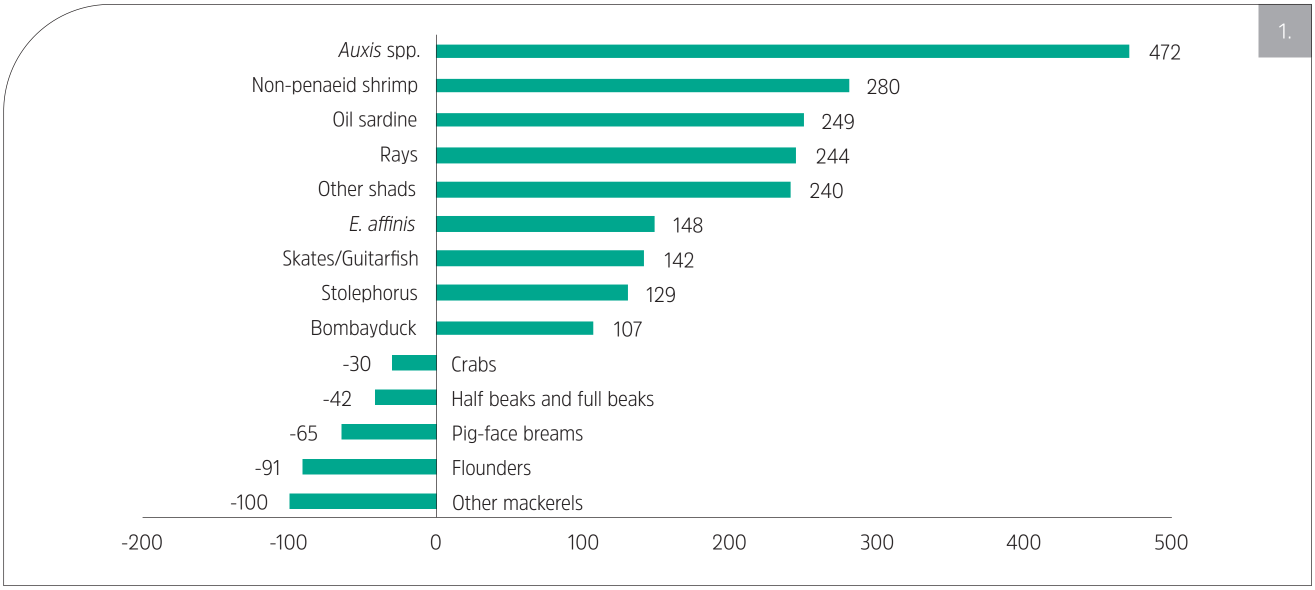


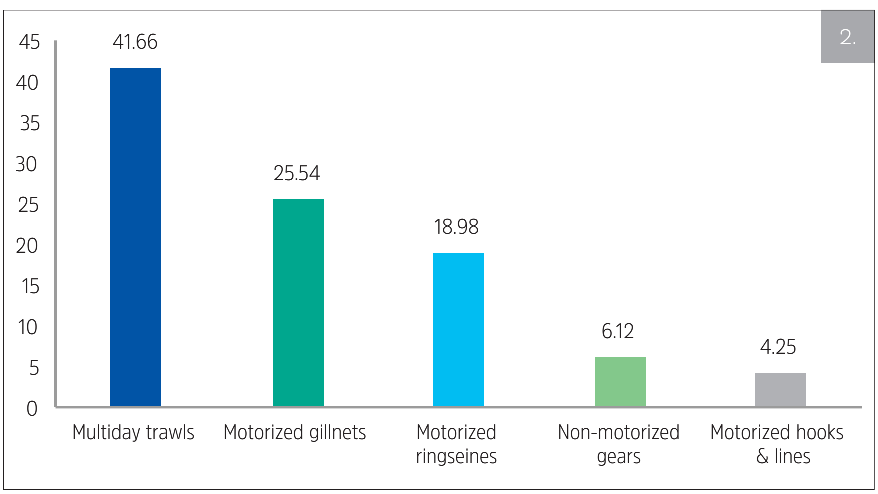


1. Mackerel being dried at Visakhapatnam
2. Annual marine landings of Andhra Pradesh (2012-2019)
3. Sector-wise contribution to marine landings of Andhra Pradesh (2019)
4. Resource profile of annual marine landings of Andhra Pradesh (2019)
5. Top 5 resources landed in Andhra Pradesh (2019)



Within the pelagic resources, the highest contribution was by lesser sardines (36393 t), followed by Indian mackerel (30726 t), ribbonfish (13490 t), Indian oil sardine (13263 t) and *Stolephorus* (9358 t). Croakers (18.3%) and silverbellies (12.7%) were the major demersal resources of Andhra Pradesh followed by other perches (10.5%), rays (7.9%) and catfish (7.5%). Penaeid shrimps contributed the highest (73.1%) to crustacean landings of the state, followed by crabs (16.7%) and non-penaeid shrimp (9.3%). The cuttlefishes contributed 66.04% (2823 t), squids 31.31% (1338 t) and octopus 2.64% (113 t) to the molluscan landings of the state.





1. Change in landings (%) from 2018 to 2019 in Andhra Pradesh
2. Gear contribution to marine landings of Andhra Pradesh (2019)

Size range of major finfish species landed in Andhra Pradesh

Species	Length range (mm)	Mean length (mm)	Sex ratio
Sphyraena jello	196-1309	517.96	1.33
Aluterus monoceros	236-623	475.64	0.92
Coryphaena hippurus	360-1050	594.36	1.95
Scomberoides commersonianus	245-700	435.06	2.2
Scomberoides lysan	232-695	469.74	3.49
Scomberoides tala	250-630	432.78	3.00
Scomberoides tol	277-415	346.3	0.83
Ariomma indicum	140-217	172	0.99
Drepane punctata	121-432	272	0.80
Drepane longimana	135-383	246	1.30
Trachninotus mookalee	168-876	513	1.53
Pomadasys kaakan	184-588	387	1.0

Diet items of major finfish species of Andhra Pradesh

Species	Prey items
Sphyraena jello	Digested finfish and shellfish, *Stolephorus, Decapterus*, Sardines, *Leiognathus*, Squid, Mackerel and other finfishes and shellfishes
Aluterus monoceros	Digested finfish and shellfish, Scales, Sciaenids, *Leiognathus* and other finfishes and shellfishes
Coryphaena hippurus	Digested finfish and shellfish, Mackerel, Carangids, Crab, Sardines and other finfishes and shellfishes
Scomberoides commersonianus	Digested finfish, *Stolephorus, Leiognathus* and other finfishes
Scomberoides lysan	Sardines, Digested finfish, *Stolephorus* and other finfishes and shellfishes
Scomberoides tala	Digested finfish and shellfish, *Stolephorus*, Ribbonfish and other finfishes
Scomberoides tol	Squilla, Digested finfish, Shrimp and Crab
Drepane punctata	Fish, stomatopods, shrimps
Drepane longimana	Fish, stomatopods, shrimps
Trachninotus mookalee	Gastropods, crabs, shrimps, bivalves
Pomadasys kaakan	Fish, shrimps, crabs

Size range of major shellfish species landed in Andhra Pradesh

Species	Length range (mm)	Mean length (mm)	Sex Ratio
Penaeus monodon	143-293	230	0.56
Penaeus indicus	148-243	183	1.18
Penaeus japonicus	108-203	178	-
Metapenaeus monocerus	108-223	148	0.97
Metapenaeus ensis	123-183	158	2.5
Metapenaeus affinis	108-193	133	1.05
Metapenaeus dobsoni	68-143	99	1.42
Solenocera crassicornis	63-128	91	0.76
Portunus sanguinolentus	64-186	121	1.28
Portunuspelagicus	124-175	156	1.25
Charybdis feriatus	64-186	107	1.67
Sepia brevimana	36-107*	72	1.59
Sepia vecchioni	48-114*	84	1.2
Sepiellainermis	36-102*	68	1.8
Amphioctopus marginatus	47-130*	91	0.75

* Dorsal Mantle Length (mm)

Major fishing gears and their catch rates

Multiday trawl nets were the major fishing gear in Andhra Pradesh, contributing 107872 t to the total marine landings. This was followed by motorized gillnets (66121 t), motorized ring seines (49136 t), non-motorized gears (15834 t) and motorized hooks & lines (11011 t). A study on the trawling intensity off Andhra Pradesh indicated that the trawling ratio (i.e. ratio of area trawled and continental shelf area) was 5.62 for the state indicating very high intensity of trawling. Though trawl nets contributed highest landings in terms of quantity, the highest catch per unit effort was observed in shore seines 1421 kg/unit. This was followed by motorized ring seines (846 kg/unit), boat seines (178 kg/unit) and motorized hooks & lines (171 kg/unit). Multiday trawl nets had a catch rate of 33 kg/h. The top resources landed by multiday trawl nets were penaeid shrimps, ribbonfish and Indian mackerel. The top resources landed by motorized gillnet and motorized ring seines were lesser sardines, Indian mackerel and Indian oil sardine. The non-motorized gears mainly landed lesser sardines, Indian mackerel and croakers. The motorized hooks & lines on the other hand, mainly landed other tunnies, billfishes, mackerel, tuna and eels.

Biology of major marine resources of Andhra Pradesh

Studies on the reproductive biology and diet of major finfish and shellfish resources landed in Andhra Pradesh were continued in 2019.

Population parameters of major pelagic fish of Andhra Pradesh

Species	L_{α} (cm)	K (y^{-1})	M	F	Z	E
Sphyraena jello	137.44	0.10	0.26	0.82	1.08	0.76
Aluterus monoceros	66.04	0.22	0.53	0.68	1.21	0.65
Coryphaena hippurus	110.15	0.11	0.29	1.05	1.34	0.78
Scomberoides commersonianus	74.45	0.24	0.54	0.88	1.42	0.62
Scomberoides lysan	74.45	0.21	0.50	0.53	1.03	0.51
Scomberoides tala	66.04	0.11	0.34	0.63	0.97	0.65
Scomberoides tol	42.94	0.44	0.94	0.30	1.24	0.24

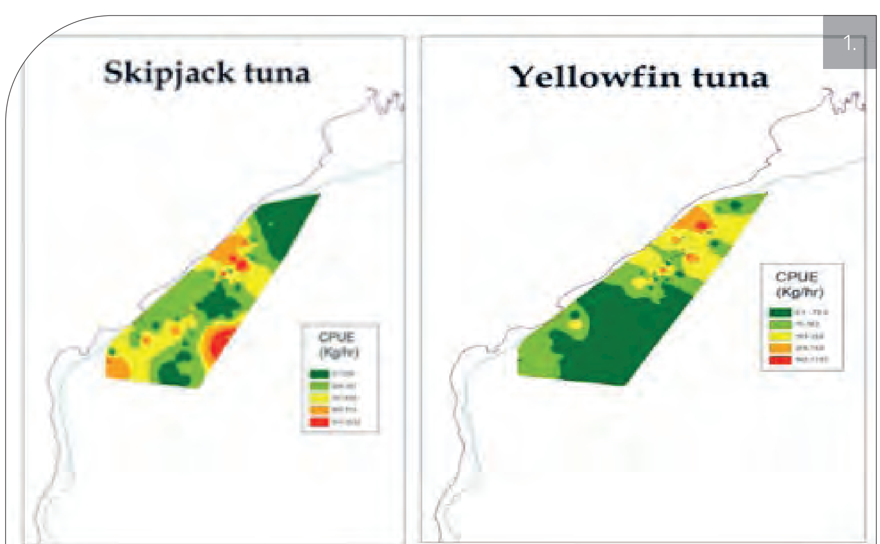
Growth rates, mortality rates and exploitation ratio for major pelagic resources landed in the state were studied during 2019. Of the 7 species studied, 6 were beyond the optimal exploitation ratio of 0.5.

Mapping of marine resources and fishing fleets

The offshore gillnet fishery primarily targeting tunas off Andhra Pradesh was studied. Catch per set of gillnet ranged from 70 kg to 3551 kg with an average catch per set being 751 kg. The highest average monthly catch was observed in January (1349 kg) and December (1221 kg). The catch was dominated by *Katsuwonus pelamis* (63.0%), followed by *Thunnus albacares* (22.1%), *Euthynnus affinis* (3.6%), *Xiphias* spp. (2.3%) and *Istiophorus* spp. (2.0%). Skipjack tuna registered highest catches in December – January with an average whereas yellowfin tuna on the other hand had the highest catch during June-August. The highest catch of skipjack tuna was found south of Visakhapatnam in areas where depth exceeded 1000 m. Yellowfin tuna on the other hand were caught mainly near the 200 m depth contour in areas north of Visakhapatnam.

Experimental trawling

A total of 14 experimental fishing trips were conducted off Visakhapatnam during 2019. The total catch in kg per trip ranged from 2 to 105. The average catch per trip was 35.3 kg. The average catch rate (kg/h) was 35.9. The major fish groups caught were ribbonfish, silverbellies, goatfish, threadfin breams and croakers.



1. Maps of high skipjack tuna and yellowfin tuna availability off Andhra Pradesh coast
2. Barracudas landed by motorized fishing units at Visakhapatnam

2.

The marine environment

Marine debris in the sea was studied during experimental trawling trips off Visakhapatnam. Debris ranged from 0.0 to 5.4 kg per trip averaging 1.5 kg per trip during 2019. The percentage contribution of debris to total catch ranged from 0 to 27 with an average of 5.8%. Monthly variations in hydro biological parameters of inshore waters off Visakhapatnam were studied. Seawater temperature ranged between 28 – 29 °C and the salinity of coastal waters ranged between 33 – 34 ppt. The nutrients and pigments also showed seasonal variations. The total chlorophyll (CHL) value on average was 1.80 mgC/m^3.

USEPA	GOOD	FAIR	POOR

Status	DIN	DEP	CHL	Over all
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Total dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP) values were 0.16 mg/L and 0.04 mg/L. As per USEPA standards for coastal waters chlorophyll values were in good condition, where as DIN and DIP were in fair state.

Economics of fishing in Andhra Pradesh

An analysis of the economics of various fishing operations in Andhra Pradesh indicated that fuel cost was the highest contributor to operating costs for the mechanized fishing sector. On the other hand, for the motorized and non-motorized sectors, crew wages contributed the highest to operating costs. Furthermore, of the motorized gears, the *naravala* (a type of gillnet) had the highest Gross Value Added as percent of Gross Revenue. For non-motorized gears, the highest GVA as percent of Gross Revenue was seen in hooks & lines.

1. Dolphinfish landed at Visakhapatnam
2. Auction of trawl landings at Visakhapatnam

Bengal & Odisha

Research Project CFD/NEC/05

Bombayduck landing at Digha Mohana

1. Trend of marine fish catch in West Bengal during 2007 - 2019
2. Monthly distribution of catch and catch rate (CPU)
3. Gear-wise contribution to the total marine fish landings of West Bengal in 2019
4. Gear-wise contribution to the total marine fish landings of West Bengal in 2019

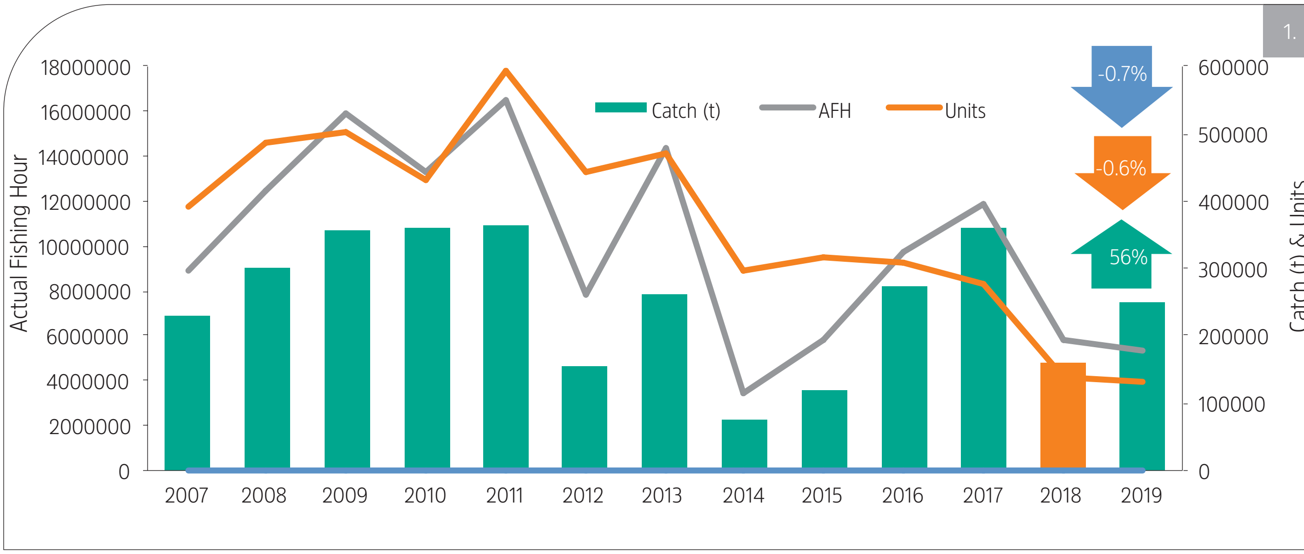
West Bengal Marine Fisheries

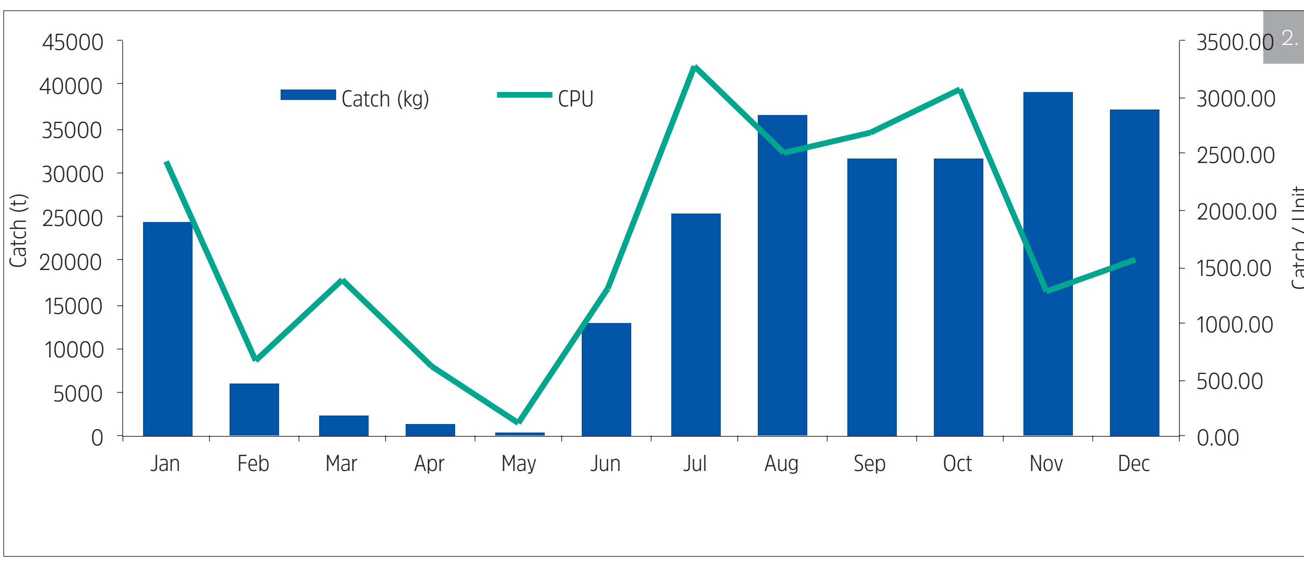
The total marine fish landings of West Bengal in the year 2019 was about 2.5 lakh t which showed a tremendous increase of about 56% compared to 2018 (1.6 Lakh t). Total number of fishing trips (coined as unit effort) and actual fishing hour (AFH) though declined marginally by 6 and 7% respectively compared to previous year, the catch increased by 56% which indicate a positive revival of fishery during 2019. Monthly catch trend showed the last two quarters (from July to December) to be the most productive period of the year and maximum abundance (CPUT) was observed in July followed by October. The resources were mainly exploited by mechanized trawlers (60%) followed by mechanized gill netters (10%), mechanized bag netters (9%). Other gears such as motorized bag netters, gill netters, hook and liners, shore seiners together contributed about 21% to the total marine fish landings of West Bengal. Pelagic resources with a landing of 1.36 Lakh t contributed maximum (54%) to the total marine fish landings of West Bengal followed by demersal resources (72000 t, 29%), crustacean resources (33000 t, 13%). Molluscan resources with a landing of about 7000 t contributed the least (3%) to the total marine fish landings of West Bengal.

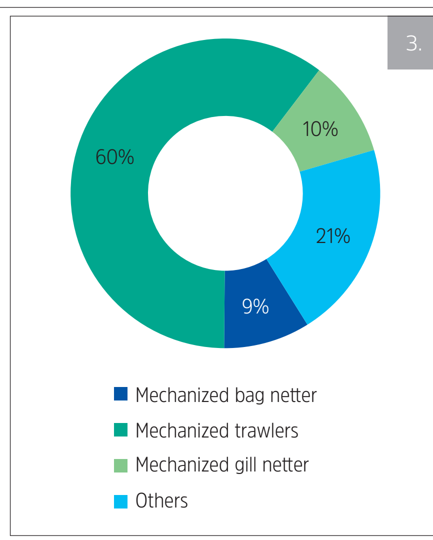
Crustacean resources

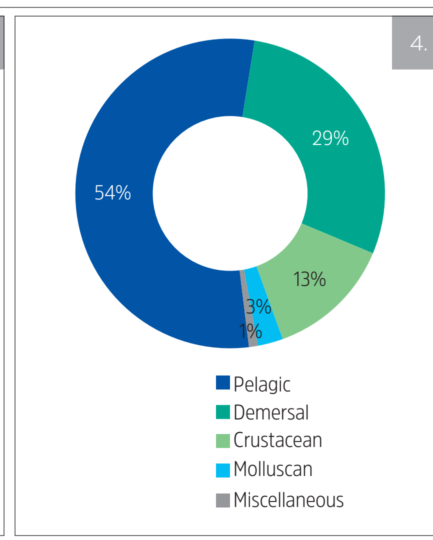
Total crustacean landings of West Bengal was about 32769 t which constituted 13% of the total marine fish landings of the state in 2019. Shrimp with a total landing of about 28000 t showed an increase of 56% compared to previous year. They contributed nearly 86% to the total crustacean landings of West Bengal. Penaeid and non-penaeid shrimp contributed nearly 63 and 23% respectively to the total crustacean landings of West Bengal.

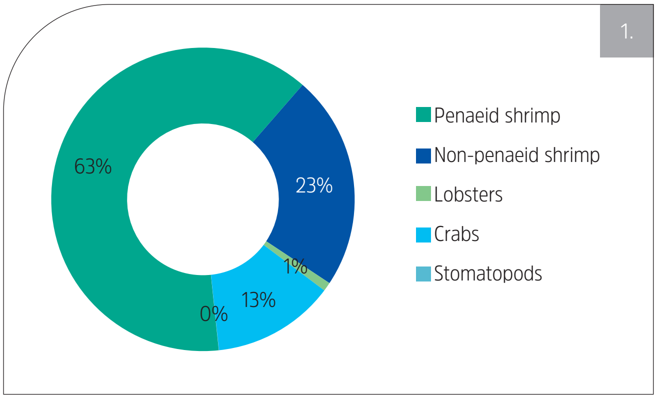
Among penaeid shrimp, the maximum contribution (27%) of shrimp landings was from *Parapenaeopsis* spp. group (7554 t) which comprised mainly of 3 species i.e., *Parapenaeopsis stylifera, Parapenaeopsis hardwickii* and *Parepenaeopsis sculptilis*. Metapenaeus spp. group mainly comprised of *Metapenaus affinis, Metapenaeus monoceros* and *Metapenaeus brevicornis* contributed nearly 4851 t of landings (17% of shrimp landings) during 2019. *Penaeus* spp. group comprised of *Penaeus indicus, Penaeus monodon, Penaeus japonicus, Penaeus semisulcatus* and *Penaeus merguiensis* which contributed nearly 3784 t of landings (14% of shrimp landings). *Solenocera* spp. group comprised of *Solenocera crassicornis, Solenocera hextii* and *Solenocera choprai* contributed about 3252 t (12% of shrimp landings) in West Bengal during 2019. *Acetes* spp., as a major non-penaeid shrimp with a landing of 4275 t contributed nearly 15% of the total shrimp landings of West Bengal during 2019.

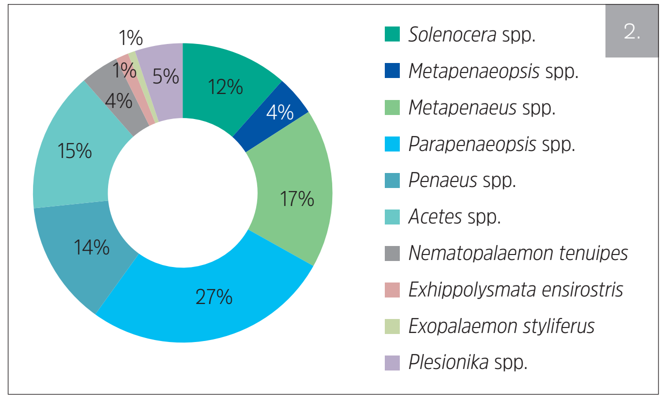

1.
Catch (t)
AFH
Units
-0.7%
-0.6%
56%
Actual Fishing Hour
Catch (t) & Units
18000000
16000000
14000000
12000000
10000000
8000000
6000000
4000000
2000000
0
600000
500000
400000
300000
200000
100000
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019


2.
Catch (kg)
CPU
Catch (t)
Catch / Unit
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


3.
60%
10%
21%
9%
Mechanized bag netter
Mechanized trawlers
Mechanized gill netter
Others


4.
54%
29%
13%
3%
1%
Pelagic
Demersal
Crustacean
Molluscan
Miscellaneous





Pelagic resources

Total pelagic fish landings was about 130768 t which constituted 54% of the total marine fish landings of the state in 2019. Among the pelagic resources maximum contribution came from bombayduck (*Harpadon nehereus*) which contributed about 21704 t (17%) followed by anchovies such as *Setipinna* spp., *Stolephorus* spp. and *Thryssa* spp. which together contributed about 21682 t (17%).

Golden anchovies, *Coilia dussumieri* along with *Coilia neglecta* contributed about 13288 t (10%) of pelagic landings of the state. Hilsa (*Tenualosa ilisha*) and ribbonfishes (*Trichiurus lepturus, Lepturacanthus savala* and *Eupleurogrammus muticus*) contributed about 11340 and 11135 t respectively which was about 9% each to the total pelagic landings of the state. About 9593 t of landings was contributed by sardines (*Sardinella fimbriata*, *Sardinella gibbosa* and *Sardinella longiceps*) which amount to 7% of total pelagic landings. Mackerel (*Rastrelliger kanagurta* and *Rastrelliger faughni*) and *Ilisha megaloptera* with landings of 6903 and 6002 t contributed 5% each to total pelagic landings. Tardoore (*Opisthopterus tardoore*) and Horse mackerel (*Megalaspis cordyla*) with landings of 5293 and 4246 t formed respectively 4 and 3% of total pelagic landings. Almost all the pelagic resource groups showed significant increase in landings compared to 2018 except for Wolf herrings and Hilsa where decrease of 18 and 33% was observed compared to 2018 landings.

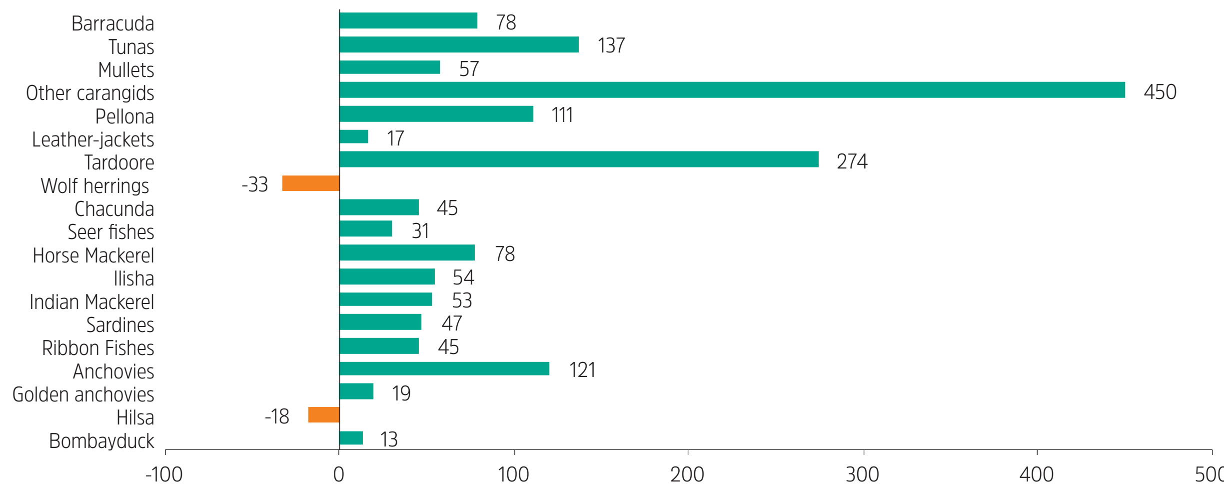
Demersal resources

Total demersal fish landings was about 71800 t which constituted 29% of the total marine fish landings of the state in 2019. Among the demersal resources maximum contribution was from Sciaenids (*Johnius* spp., *Nibea maculata, Otolithes* spp., *Pennahia anea*, *Protonibea diacanthus, Panna microdon, Pterotolithus maculata* and *Kathala axillaris*) which contributed about 24873 t (35%) to the total demersal fish landings. Pomfrets (*Pampus argenteus, Parastromateus niger* and *Pampus chinensis*) and Catfishes (*Arius spp., Plicofollis dussumieri, Netuma thalassina* and *Osteogeneiosus militaris*) formed about 12757 and 6894 t respectively which were about 18 and 10% of the total demersal landings. About 6669 t of flatfishes (*Cynoglossus* spp. and *Psettodes erumei*) was also landed which contributed about 9% of the total demersal landings. Apart from this perches and sharks contributed nearly 4% each.

Fishery biology

Data on length and weight were collected regularly and biological investigation were also carried out to assess the growth parameters (L_{α}, K and t_0), mortality and exploitation parameters (M, F, Z and E), reproductive biology parameters (fecundity, age/length at maturity, spawning periodicity through ova diameter study, peak breeding season), food and feeding habits have also been carried out for 17 selected commercially important marine species of the state.

3.



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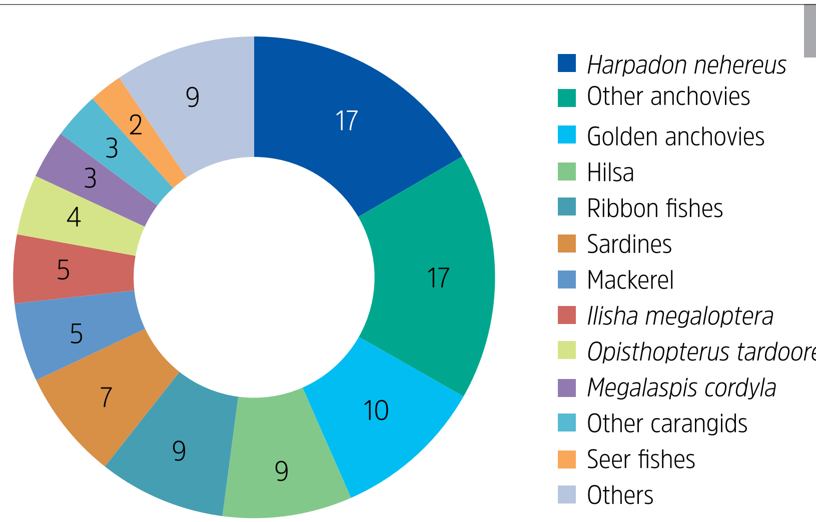


1. Resource contribution to the crustacean landings of West Bengal during 2019
2. Species group contribution to the shrimp landings of West Bengal during 2019
3. Percentage change in the landings of major pelagics during 2019 compared to 2018
4. Resource group contribution % to the pelagic landings of West Bengal during 2019

Economic efficiency of mechanized fishing in Digha, West Bengal'

Digha Mohana is a major fish landing and auction centre in the East Medinipur District of West Bengal providing livelihood support and contributing to fisheries export. A study was conducted to analyse the economic efficiency of mechanized trawl fishing in Digha. Primary data on investment, operational costs and earnings of mechanized trawlers across different duration of fishing were collected from 10 units in each category operating at Digha fisheries harbor. The analysis revealed that average total cost per fishing day was high for multiday fishing involving more than 6 days than those with less than 6 days. MD trawlers operating less than 6 days were found to be labour efficient as well as earned more carbon credit by releasing less carbon dioxide during fishing expeditions in terms of fuel quantity and the value as compared to MD trawlers operating more than 6 days. The economic efficiency assessed through the different indicators revealed that trawl operations of more than 6 days being more profitable than those with less than 6 days operations.

1. Black pomfret landing at Digha Mohana

Odisha

Analysis of fish landings from 2007-2019 revealed the highest catch of 322683.8 t in 2011 followed by gradual decline and lowest during 2018. Total marine landings of Odisha coast during 2019 was estimated as 102143 t registering an increase of about 15% compared to the previous year's landings of 89178 t. District-wise catch analysis showed that Balasore contributes highest catch of about 47907 t (46%) followed by Jagatsinghpur 29222 t (28%). Monthly catch analysis of 2019 indicated that the fishery attained its peak during the second and third quarter of the year registering highest catch in October, after which the catch declined gradually with the lowest in May due to the monsoon fishing ban. Group-wise analysis of catch in 2019 indicated the pelagic contribution of 53974 t (53%) followed by demersal 29881 t (29%), crustaceans 13198 t (13%), molluscs 3688 t (4%) and miscellaneous 1401 t (1%).

Life history, mortality and exploitation parameters of selected commercially important marine species of West Bengal

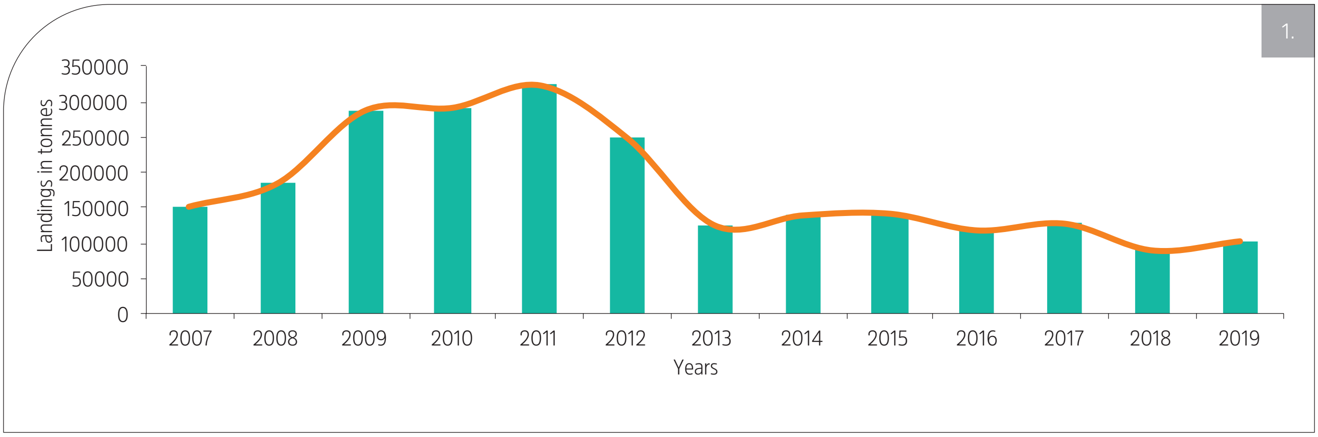
Species/Parameter	L^{∞}(cm)	K (y^{-1})	M (y^{-1})	F (y^{-1})	Z (y^{-1})	E_{Cur}	LC_{50} (cm)	LM_{50} (cm)	$E_{0.1}$	$E_{0.5}$	E_{MAX}
Plicofollis layardi	47.25	0.47	0.96	0.49	1.45	0.34	24.75	38.50	0.56	0.35	0.70
Cynoglossus arel	49.35	0.40	0.85	0.72	1.57	0.46	18.65	20.50	0.50	0.32	0.63
Nemipterus japonicus	30.45	0.54	1.19	2.06	3.25	0.63	7.82	13.50	0.42	0.29	1.00
Pampus argenteus	25.20	0.67	1.44	0.34	1.78	0.19	12.66	19.50	0.56	0.36	0.70
Parastromateus niger	45.15	0.40	0.88	0.65	1.52	0.42	12.50	31.50	0.42	0.29	0.52
Otolithes ruber	49.88	0.25	0.63	1.03	1.66	0.62	17.50	21.50	0.51	0.32	0.62
Coilia dussumieri	18.90	1.10	2.16	4.17	6.33	0.66	14.28	14.10	0.69	0.41	0.79
Harpadon nehereus	37.80	0.80	1.45	0.89	2.34	0.38	21.60	22.60	0.60	0.38	0.75
Megalaspis cordyla	64.05	0.50	0.92	0.60	1.52	0.40	19.91	25.70	0.45	0.31	0.53
Lepturacanthus savala	105.00	0.50	0.80	0.59	1.39	0.42	40.49	37.50	0.47	0.32	0.60
Scomberomorus guttatus	61.43	0.66	1.11	0.67	1.78	0.37	22.71	38.50	0.45	0.32	0.59
Sardinella gibbosa	26.78	0.80	1.59	7.19	8.78	0.82	16.59	13.50	0.66	0.39	0.80
Parapenaeopsis sculptilis	220.50	1.80	2.86	8.63	11.49	0.75	142.10	105.00	0.66	0.39	0.75
Parapenaeopsis stylifera	141.80	1.80	3.23	5.78	9.01	0.64	108.70	80.00	0.70	0.42	0.80
Penaeus monodon	315.00	1.60	2.40	1.96	4.36	0.45	168.50	180.00	0.55	0.37	0.70
Penaeus semisulcatus	273.00	1.70	2.60	3.13	5.72	0.55	168.70	145.00	0.65	0.39	0.75
Solenocera crassicornis	136.50	1.90	3.39	2.62	6.01	0.44	72.40	80.00	0.66	0.41	0.80

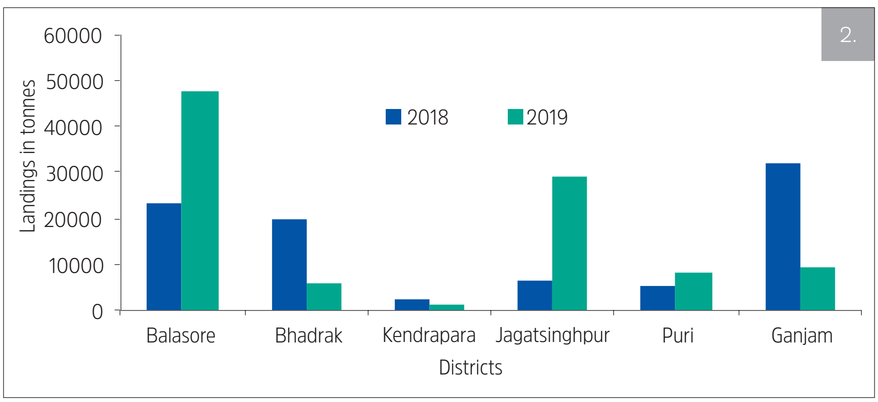
The average operational expenses of trawl operations per trip from Digha, West Bengal'

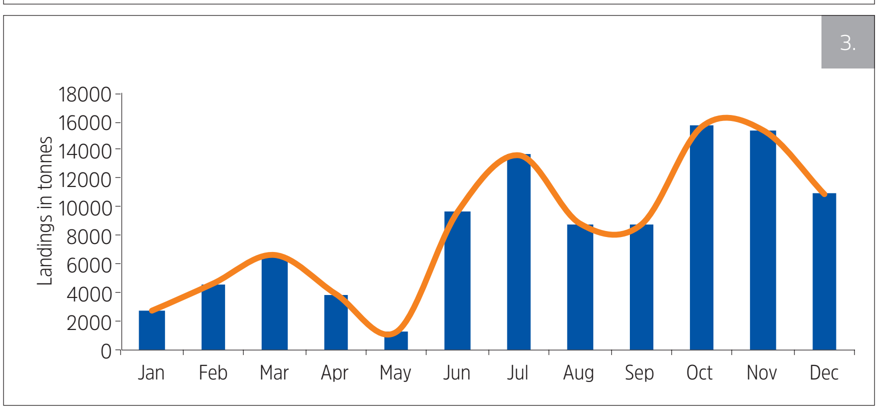
Components	MD >6D		MD <6D	
	Amount	Share	Amount	Share
Starter Oil	7811.11	2.45	3233.33	1.27
Fuel	144825.6	45.44	91735	36.04
Crew share	89544.89	28.10	81335	31.95
Provisions	20777.78	6.52	16333.33	6.42
Ice	13844.44	4.34	14000	5.50
Auction charges	26997	8.47	24916	9.79
Water Charges	2008.89	0.63	2833.33	1.11
Other	12888.89	4.04	20166.67	7.92
Total	318698.55	100.00	254552.66	100.00

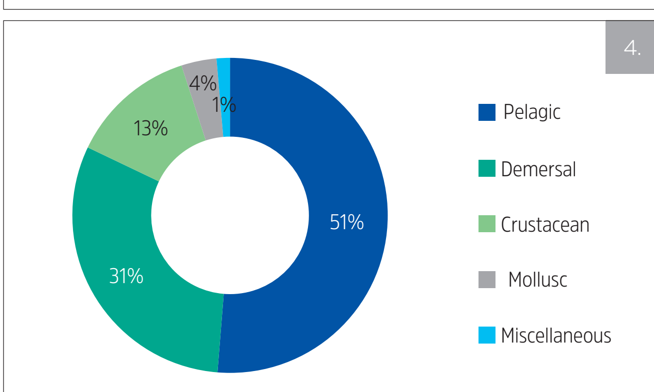
Indicators for assessing economic efficiency of trawlers operated from Digha, West Bengal

Profitability Ratios	More than 6 days	Less than 6 days
Operating Ratio	0.46	0.49
Rate of Return	1.16	1.00
Profitability Ratio	1.19	1.02
Net Profit Ratio	0.54	0.51
Input- Output Ratio -(Total input cost/Gross revenue)	0.33	0.34









Pelagic resources

The annual landings of pelagic fishery resources was estimated at 52370 t, which is nearly 51% of the total marine fish landings of Odisha coast in 2019, registering a decline of 12.4% compared to 2018. Major pelagic resources were other clupeids (15405 t), lesser sardine (3867 t), ribbonfish (3624 t), Indian mackerel (3012 t), *Thryssa* (2687 t), horse mackerel (2317 t), Hilsa shad (2207 t), oil sardine (2207 t), bombayduck (2132 t) and *Coilia* (1993 t).

Demersal resources

The annual landings of demersal fishery resources was estimated at 31485 t, contributed nearly 31% of the total marine fish landings of Odisha coast in 2019 registering an increase of 56.8% compared to 2018. Major demersal resources were croaker (9198 t), catfish (5304 t), other perches (3079 t), black pomfret (2275 t), silver pomfret (1699 t), silverbellies (1686 t), soles (1604 t), Chinese pomfret (1303 t), eels (854 t) and threadfin breams (747 t).

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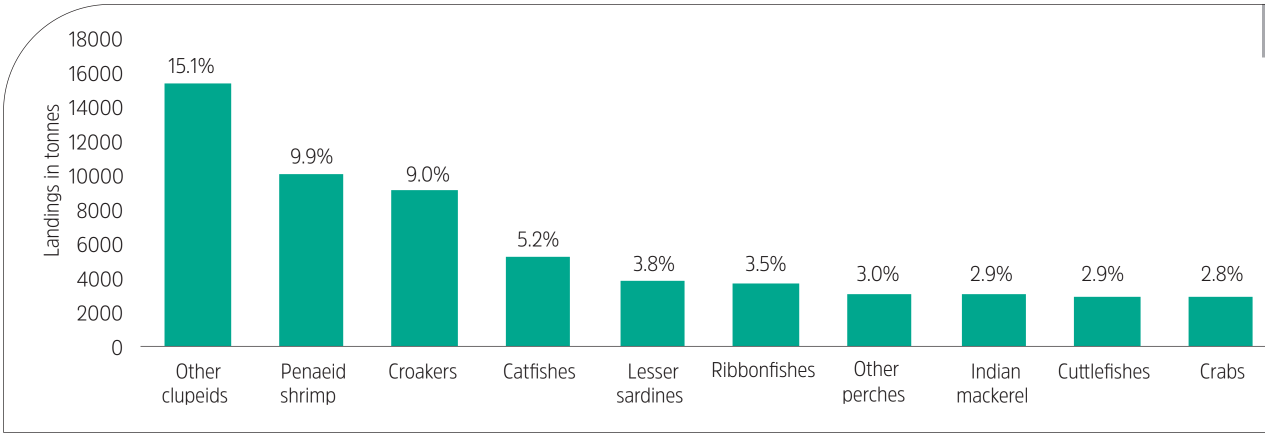

1. Trend of marine fish catch in Odisha coast during 2007-2019
2. District-wise marine landings of Odisha during 2018 and 2019
3. Month-wise marine landings in Odisha coast during 2019
4. Group-wise percentage contribution to the total marine fish landings of Odisha in 2019
5. Catch status of top 10 fishery resources along Odisha coast during the year 2019
6. Catch status of top 10 pelagic resources during 2019
7. Catch status of top 10 demersal resources during 2019

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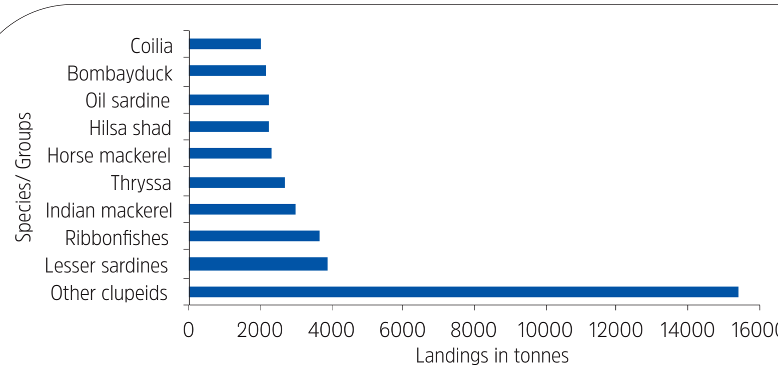

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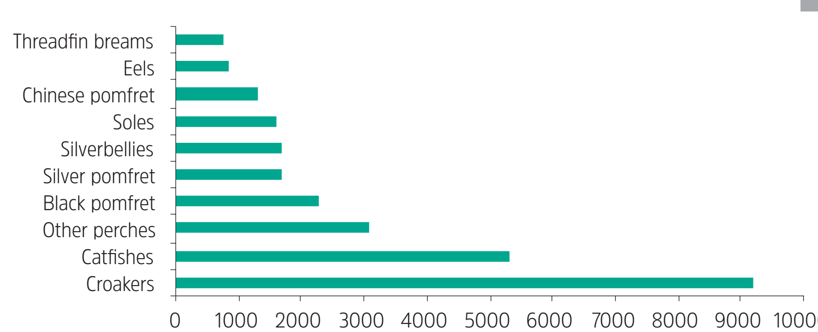

Molluscan resources

Cephalopods were the major group of molluscs with an annual landing of 3.66 thousand t in the year 2019 which formed nearly 3.6% to the total marine landings of the state. Highest catch of cuttlefishes were observed during October and November whereas for squid it was March, June and November. Total landings of cephalopods witnessed a 175.5% increase from previous year, and comprising of 4 cuttlefish (79%)

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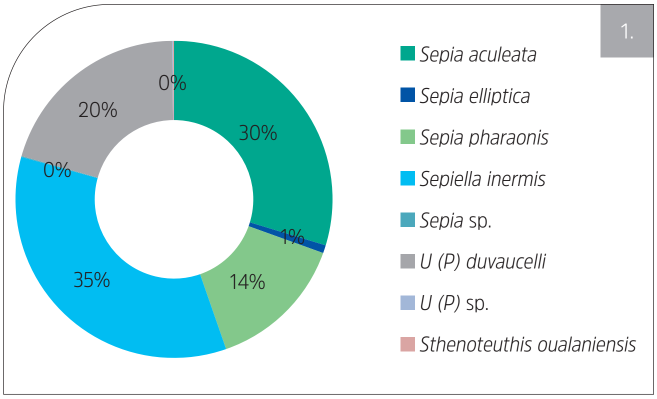

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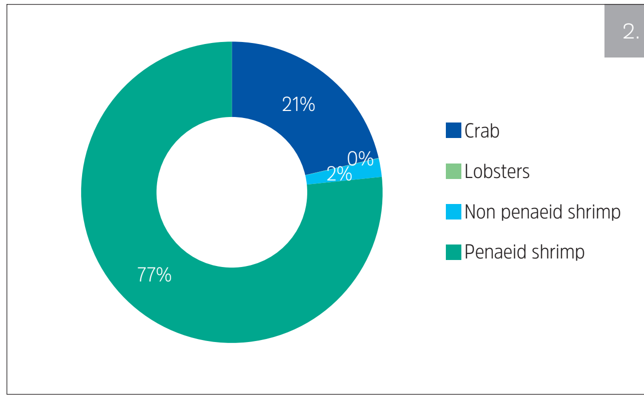
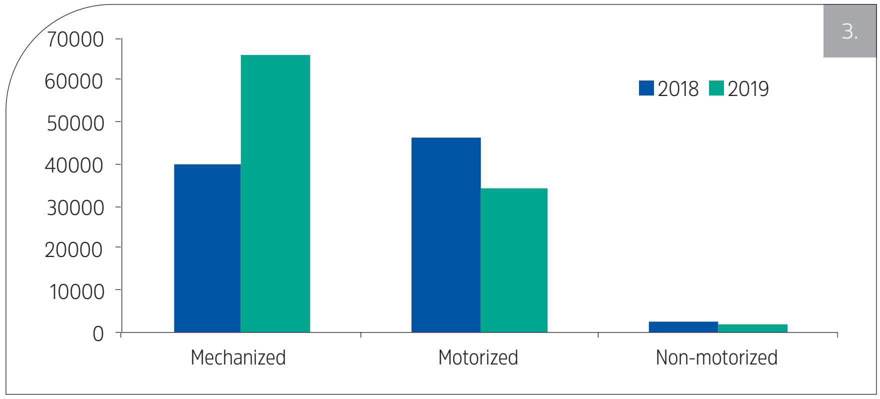


and 2 squid (21%) species. *Sepiella inermis* (1269.3 t) had the highest contribution to total cephalopod landings followed by *Sepia aculeata* (1087.6 t), *Uroteuthes (P.) duvaucelli* (747.4 t), *Sepia pharaonis* (519 t) and *Sepia elliptica* (29.7 t). All species of cephalopod showed increasing catch value except *S. elliptica* whereas *S. inermis* showed highest percentage of increase in catch compared to previous year. Highest landing of cuttlefishes was observed during October and November. Interestingly, 99% of cephalopod catch was obtained from multiday trawlers operating from Paradip, Dhamra, Balaramgadi and Bahabalpur landing centres, and rest 1% was from bagnets, gill nets and ring seines operating from the coast.

Crustacean resources

Crustaceans together contributed 13200 t, nearly 12.9% to total landing of Odisha in 2019. a percentage change of 130.35 from the previous year landing. The major resources were penaeid shrimp (10,114.4 t) followed by crabs (2816.6 t), non-penaeid shrimp (262.5 t) and least was by lobsters (4.6 t). Penaeid shrimp shares nearly 76.6% of the total crustacean landings and represented by *Penaeus, Parapenaeus, Metapenaeus* and *Solenocera* genera. *Parapenaeopsis stylifera* was the highest contributor followed by *Metapenaeus dobsoni, Parapenaeopsis hardwicki*. Among penaeus *P. indicus* recorded highest landings in 2019. October and November recorded highest landings of shrimp and lobsters in 2019. Unlike previous years multiday trawl (60%) contributed highest followed by outboard gillnetter (23%) and others. Crabs shared 2.75% of the total marine landings of the state and nearly 21.34% of total crustacean landings. September and October recorded highest landing in 2019. Crabs comprised of only 3 major species. *P. sanguinolentus* (1677.03 t) having highest landings followed by *P. pelagicus* (700.8 t), *C. feriatus* (438.2 t) and minor contribution from other portunid crabs. Catch of crabs and lobsters increased (54.9% and 76.9% respectively). Highest catch of crab (nearly 87%) was from multiday trawl followed by outboard gillnetter and mechanised gillnetter (each 5%), non-motorised (2%) and rest is contributed by other gears.

1. Species wise contribution to total cephalopod landings of Odisha, 2019
2. Percentage contriibution to total crustacean landings of Odisha during 2019
3. Sector-wise contribution to the total marine fish landings of Odisha coast in 2019



Comparison of landing (%) of cephalopod and crustacean species from Odisha coast during 2018 and 2019

Resources	Landings (in Kg)		% change
	2019	2018	
Cephalopods			
Sepia aculeata	1087641	387570	180.63
Sepia elliptica	29676	339740	-91.27
Sepia pharaonis	519055	102679	405.51
Sepiella inermis	1269280	77829	1530.86
Sepia sp.	3240	51498	-93.71
U (P) duvaucelli	747444	375295	99.16
Total Cephalopod	3663371	1334611	174.49
Crabs			
Charybdis feriatus	438188	379909	15.34
Portunus pelagicus	700850	304379	130.25
Portunus sanguinolentus	1677329	964886	73.84
Crab Total	2816595	1818224	54.91
Shrimp			
Penaeus monodon	428629	98800	333.85
Penaeus semisulcatus	54891	5804	845.74
Penaeus merguiensis	506178	2862	17586.16
Penaeus japonicus	8945	5929	50.87
Penaeus indicus	731721	133056	449.93
Parapenaeopsis uncta	139098	78215	77.84
Parapenaeopsis sculptilis	166412	336608	-50.56
Parapenaeopsis hardwickii	1479860	15517	9437.02
Parapenaeopsis stylifera	3282122	1642608	99.81
Metapenaeus monoceros	1364	104786	-98.70
Metapenaeus brevicornis	415764	34272	1113.13
Metapenaeus sp.	5984	89251	-93.29
Metapenaeus dobsoni	1536521	525823	192.21
Solenocera sp.	1056983	620990	70.20
Penaeus group	1730364	298831	479.04
Metapenaeus group	2030461	754132	169.24
Metapenaeopsis group	229087	35552	544.37
Parapenaeopsis group	5067492	2152388	135.44
Total Penaeid shrimp	10114387	3861893	161.90
Lobsters	4657	2586	80.08

Gear wise contribution

The sector-wise contribution to the total marine fish landings of Odisha coast during the year 2019 revealed that the maximum catch was contributed by mechanized 66150 t (65%) followed by motorised 33972 t (33%) and non-mechanised 2021 t (2%). Similarly, gear-wise analysis shown highest catch by MDTN (multiday mechanised trawl) with 61652 t (60%) followed by OBGN (outboard gillnet) with 22692 t (22%).

Sample size, length range, mean length and sex ratio of important pelagic demersal, crustacean and molluscan resources studied during the year 2019

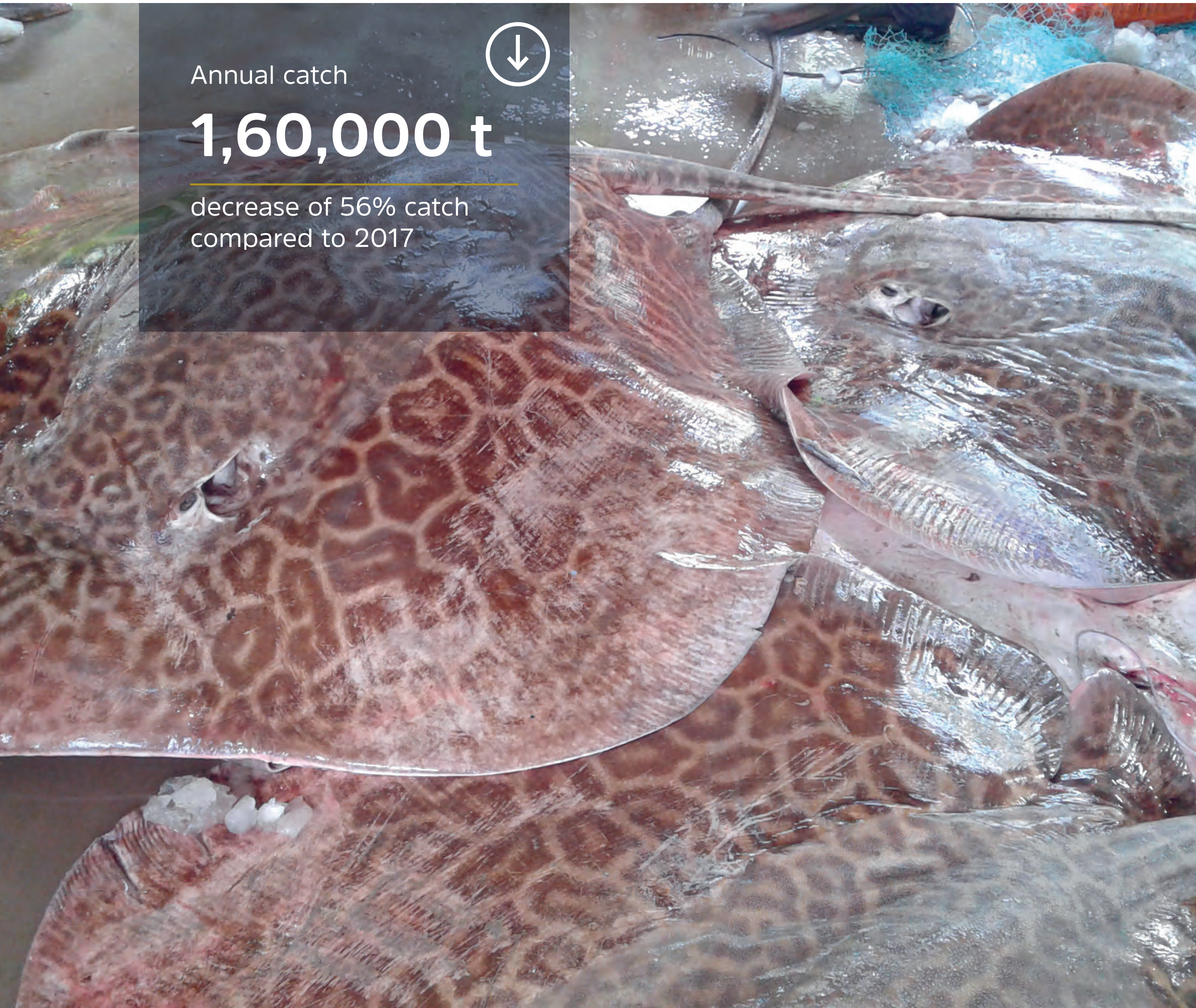
Species	Sample size (n)	Length range (cm)	Mean length (cm)	Sex ratio (M:F)	Maturity (%)
Sillago vincenti	235	12.1-35.0	22.9	1.2	69.4
S. indica	553	3.7-25.2	13.3	1.1	33.1
Sillaginopsis panijus	622	7.8-40.3	24.0	8.2	70.0
Otolithes ruber	185	19.1-48.4	28.0	1.3	48.6
Plicofollis layardii	245	10.4-48.5	32.6	2.0	40.0
P. dussumieri	99	14.4-72.4	35.4	1.4	7.1
Rhabdosargus sarba	209	7.9-37.3	18.4	1.8	39.2
Trichiurus lepturus	310	10.7-40.6	23.6	2.7	61.0
Megalaspis cordyla	248	9.4-46.6	26.1	1.3	46.4
Ilisha megaloptera	225	18.3-38	23.9	2.3	44.9
Sardinella longiceps	112	12.9-19.6	17.2	1.4	65.2
Sepiella inermis	767	2.0-8.8	5.00	0.66	40.0
Sepia pharonis	51	10.2– 29.1	21.06	0.54	88.0
Uroteuthes (P.) duvaucelli	976	4.3-21.2	8.6	0.60	47.2
Sepia aculeata	412	3.8-20.0	11.4	0.64	59.0
Portunus sanguinolentus	250	3.9-17.9	11.7	2.28	73.5
P. pelagicus	358	5.8-19.6	12.2	1.03	51.7
Charybdis feriata	202	5.3-13.2	9.93	1.04	45.5
Parapenaeopsis stylifera	828	5.2-10.3	8.02	4.14	54.1
Solenocera crassicornis	1680	3.4-10.5	7.92	5.61	56.6
Penaeus monodon	103	6.8-27.6	18.51	1.23	52.0

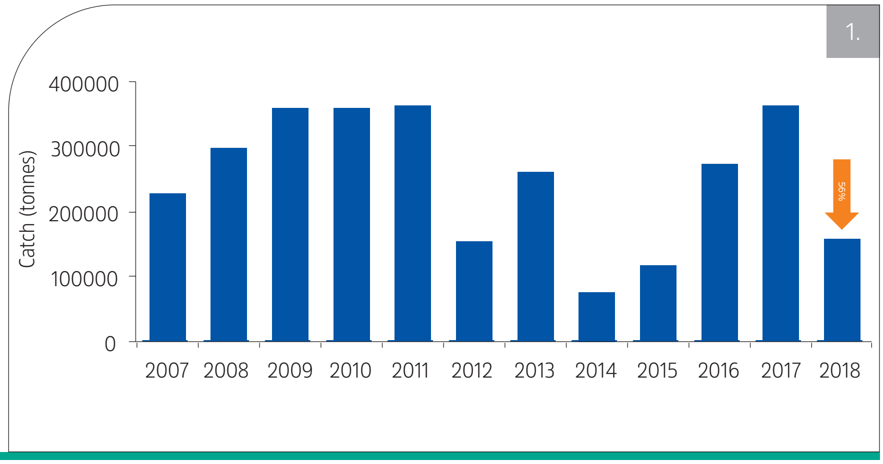
Fishery Biology

Biological investigation to assess the growth parameters (L_∞, K and t_0), mortality and exploitation parameters (M, F, Z and E), reproductive parameters (fecundity, age/length at maturity, spawning periodicity through ova diameter study, peak breeding season), food and feeding habits have also been initiated for 21 selected commercially important species of pelagic, demersal, crustacean and molluscan resources along Odisha coast.

Bengal & Odisha 2018

Research Project: CFD/NEC/05





1. Marine fish catch trend of West Bengal coast during 2007-2018
2. *Cynoglossus* sp. landings at Digha, West Bengal

West Bengal: The total marine fish landings of West Bengal during 2018 was 1.6 lakh t which decreased by about 56% compared to the previous year (3.6 lakh t). Analysis of catch and effort data for the period 2007-2018 revealed that the highest catch (3.65 lakh t) was in 2011 which fluctuated a lot since then. The unusual decrease in the marine fish landings in 2018 is mainly due to decrease in fishing effort which reduced by about 49 and 52% in terms of fishing units and actual fishing hours (AFH) respectively compared to previous year mainly due to adverse natural calamities like low pressure and cyclones. The monthly catch trend showed the last quarter (October, November and December) as the maximum productive period of the year with maximum catch and catch rate (CPUH) being observed in December. Higher catch and catch rate (CPUH) were also observed during January and February which gradually decreased towards March before the onset of fishing ban during middle of April to June. The catch though decreased during the fishing ban, the catch rate (CPUH) from the traditional fishing crafts and gears (20 kg/h) maintained itself near the average catch rate of the year (26 kg/h). Maximum contribution to the marine fish landings was observed from pelagic resources (90,000 t) followed by demersal (44,000 t), crustacean (22,000 t) and molluscan resources (2.7 thousand t).

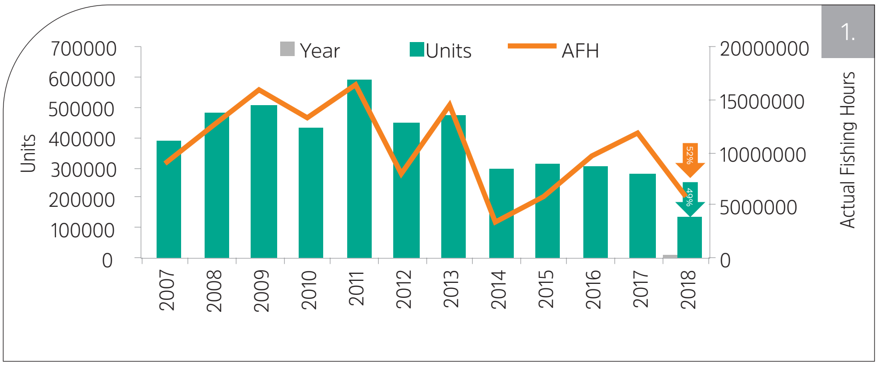
Pelagic resources: With an annual landing of about 90,000 t, the pelagic fishery resources contributed nearly 56% to the total marine fish landings. Major resources were bombayduck (19260 t), hilsa (13827 t), golden anchovies (11127 t), anchovies (9821 t), ribbonfishes (7658 t), sardines (6507 t), Indian mackerel (4503 t), ilisha (3893 t), horse mackerel (2387 t), seerfishes (2232 t), chacunda (1577 t), wolf herrings (1517 t), tardoores (1417 t), leatherjackets (1345 t) and other carangids (744 t). Catch of most of the resources decreased tremendously except for golden anchovies, tardoore and other carangids.

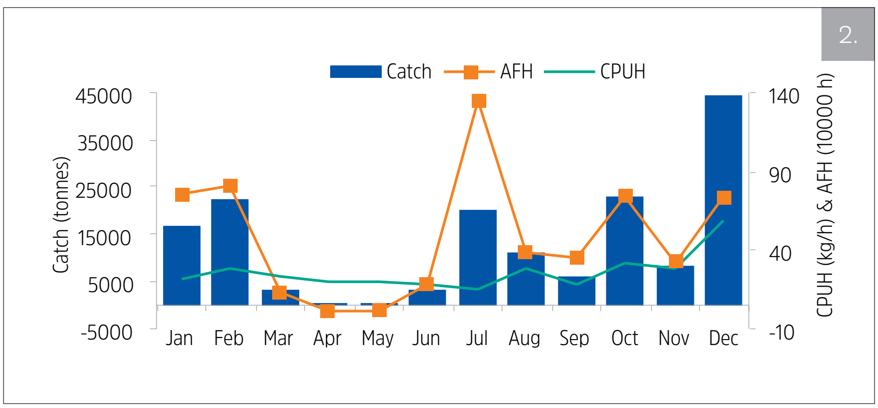
Demersal resources: Demersal fishery resources contributed nearly 27% (44,000 t) to the total marine fish landings. Major resources were sciaenids (11332 t), pomfrets (8398 t), catfishes (6458 t), flatfishes (4730 t), sharks (1830 t), eels (1738 t), threadfinbreams (1386 t), rays (1091 t), goatfishes (857 t), silverbellies (740 t), whitings (607 t), threadfins (591 t), groupers (578 t), terapons (488 t), skates (457 t) and lizardfishes (254 t). Catch of most of the resources decreased except for flatfishes, eels, silverbellies, groupers and skates. Among these groupers

2.

Changes in the landings of major pelagic groups in 2018 compared to 2017

Pelagic resources	Landings (kg)		%Change
	2018	2017	
Bombayduck *Harpadon nehereus*	19260014	37951807	-49
Hilsa *Tenualosa ilisha*	13826917	57990926	-76
Golden anchovies *Coilia dussumieri*	11126953	10089726	10
Anchovies *Setipinna taty, Stolephorus waitei, Stolephorus indicus, Stolephorus commersonnii, Thryssa mystax, Thryssa dussumieri, Thryssa setirostris*	9821197	12983916	-24
Ribbonfishes *Trichiurus lepturus, Lepturacanthus savala, Eupleurogrammus muticus*	7658086	12671094	-40
Sardines *Sardinella gibbosa, Sardinella fimbriata, Sardinella longiceps, Escualosa thoracata, Dussumieria acuta*	6507104	31917507	-80
Indian mackerel *Rastrelliger kanagurta*	4503656	20258483	-78
Ilisha *Ilisha megaloptera*	3893917	14405382	-73
Horse mackerel *Megalaspis cordyla*	2387052	11744883	-80
Seer fishes *Scomberomorus guttatus, Scomberomorus commerson*	2232048	5443148	-59
Chacunda *Anodontostoma chacunda*	1577009	5333512	-70
Wolf herrings *Chirocentrus nudus, Chirocentrus dorab*	1516487	5610394	-73
Tardoore *Opisthopterus tardoore*	1416546	1142622	24
Leather-jackets *Scomberoides tol, Scomberoides tala, Scomberoides lysan, Scomberoides commersonnianus*	1345206	3126675	-57
Other carangids *Rachycentron canadum, Alepes djedaba, Atropus atropos, Alectis indica, Caranx ignobilis, Selar crumenophthalmus*	744317	447771	66
Mullets *Mugil cephalus, Chelon planiceps, Chelon parsia*	540775	901376	-40
Tunas *Auxis thazard, Euthynnus affinis, Thunnus tonggol*	180989	265457	-32
Barracudas *Sphyraena barracuda, Sphyraena obtusata*	101283	171862	-41





1. Effort (AFH) trend of West Bengal coast during 2007-2018
2. Monthly distribution of catch, effort (AFH) and catch rate (CPUH) of West Bengal coast
3. Group wise contribution to the total marine fish landings of West Bengal coast in 2018
4. Gear-wise contribution to the total marine fish landings of West Bengal coast in 2018

Changes in the landings of major demersal groups in 2018 compared to 2017

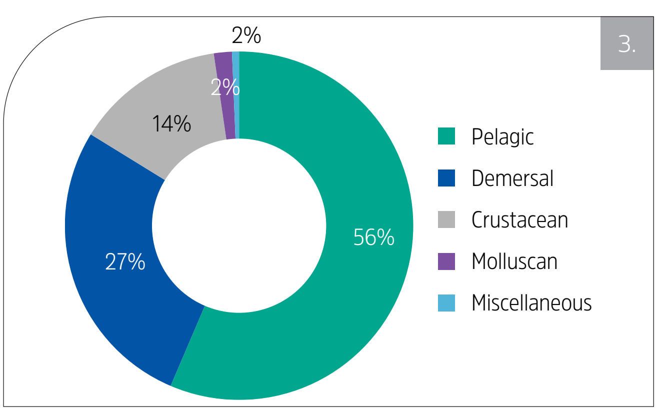
Demersal resources	Landings (kg)		%Change
	2018	2017	
Sciaenids *Johnius dussumieri, Johnius carutta, Johnius borneensis, Otolithes cuvieri, Otolithoides biauritus, Otolithes ruber, Nibea maculata, Protonibea diacanthus, Pennahia anea*	11331750	15808210	-28
Pomfret *Pampus argenteus, Pampus chinensis, Parastromateus niger*	8398287	15078024	-44
Catfishes *Plicofollis tenuispinis, Netuma thalassina, Plicofollis dussumieri, Osteogeneiosus militaris*	6457942	27354109	-76
Flatfishes *Cynoglossus macrolepidotus, Cynoglossus macrostomus, Psettodes erumei*	4730499	4382811	8
Sharks *Carcharhinus sorrah, Carcharhinus dussumieri, Carcharhinus leucas, Scoliodon laticaudus, Mustelus mosis, Rhizoprionodon oligolinx, Rhizoprionodon acutus, Chiloscyllium griseum, Alopias superciliosus*	1829915	2736007	-33
Eels *Congresox talabanoides, Congresox talabon, Muraenesox cinereus*	1738310	1123952	55
Threadfinbreams *Nemipterus randalli, Nemipterus japonicus*	1385711	2195336	-37
Rays *Himantura* spp., *Dasyatis* spp., *Mobula* spp., *Manta* spp., *Aetobatus narinari, Aetobatus flagellum*	1091469	1433669	-24
Goatfishes *Upeneus sulphureus, Upeneus vittatus*	856872	848679	1
Silverbellies *Secutor insidiator, Photopectoralis bindus, Nuchequula blochii, Eubleekeria splendens, Leiognathus equula*	740428	426982	73
Whitings *Sillago sihama, Sillaginopsis domina*	606925	2611312	-77
Threadfins *Eleutheronema tetradactylum, Leptomelanosoma indicum, Polynemus paradiseus*	591158	2820890	-79
Groupers *Epinephelus diacanthus, Epinephelus chlorostigma, Epinephelus fasciatus*	577716	128305	350
Terapon *Terapon jarbua*	487654	1363491	-64
Skates *Rhinobatos granulatus, Rhinobatos linoteus*	457216	176519	159
Lizardfishes *Saurida tumbil, Trachinocephalus myops*	254344	591704	-57

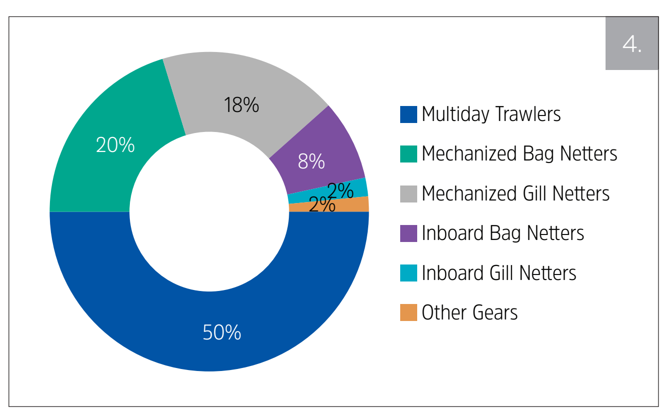
Change in the landings of major crustacean groups in 2018 compared to 2017

Crustacean resources	Landings (kg)		%Change
	2018	2017	
Penaeid shrimps	13507974	25142496	-46
Solenocera hexti, S. crassicornis	981193	1574244	-38
Metapenaeopsis stridulans	77701	60112	29
Metapenaeus monoceros, M. brevicornis and *M. affinis*	4322144	9012941	-52
Parapenaeopsis stylifera, P. sculptilis, P. hardwickii, P. uncta	4781346	7461291	-36
Penaeus indicus, P. monodon, P. semisulcaus, P. japonicus	3345590	7033908	-52
Non-penaeid shrimps	4544652	6301018	-28
Acetes indicus	2667097	2547029	5
Nematopalaemon tenuipes	21432	Not reported	0
Plesionika spp.	1856123	3753989	-51
Lobster *Panulirus homarus, P. polyphagus*	102792	309895	-67
Crabs	4062891	3789000	7
Portunus sanguinolentus, P. pelagicus	3425703	3266314	5
Charybdis feriatus, C. annulata	637002	521328	22

Change in the landings of major molluscan groups in 2018 compared to 2017

Molluscan resources	Landings (kg)		%Change
	2018	2017	
Uroteuthis spp.	284853	230926	23
Sepia spp.	2105651	4264714	-51
Sepiella spp.	107756	53733	101





Life history and exploitation parameters of some of the selected species of West Bengal in 2018

Species	*Lepturacanthus savala*	*Sardinella gibbosa*	*Megalaspis cordyla*	*Scomberomorus guttatus*	*Coilia dussumieri*	*Harpadon nehereus*
Catch	1733.05 t	3456.22 t	2387.05 t	1661.16 t	11028.28 t	19260.01 t
Length range	225-775 mm	105-245 mm	125-385 mm	130-580 mm	75-165 mm	150-350 mm
Mode length	550 mm	170 mm	155 mm	280 mm	140 mm	260 mm
Lm_{50}	375.2 mm	155 mm	257 mm	384.5 mm	141 mm	215 mm
Fecundity	15227	69205	268741	134289	76782	102277
Lc_{50}	480.2 mm	128 mm	279 mm	203.4 mm	120.9 mm	226 mm
L_∞	813.8 mm	257.25 mm	393.8 mm	593.3 mm	173.5 mm	367.5 mm
K	0.41 y^{-1}	0.86 y^{-1}	0.58 y^{-1}	0.65 y^{-1}	0.93 y^{-1}	0.85 y^{-1}
T_{MAX}	7.31 y^{-1}	3.48 y^{-1}	5.17 y^{-1}	4.61 y^{-1}	3.22 y^{-1}	3.52 y^{-1}
M	0.63 y^{-1}	1.32 y^{-1}	0.89 y^{-1}	1.00 y^{-1}	1.43 y^{-1}	1.31 y^{-1}
F	1.30 y^{-1}	4.09 y^{-1}	1.56 y^{-1}	1.07 y^{-1}	2.02 y^{-1}	2.10 y^{-1}
Z	1.93 y^{-1}	5.41 y^{-1}	2.45 y^{-1}	2.07 y^{-1}	3.45 y^{-1}	3.41 y^{-1}
E	0.67	0.76	0.64	0.52	0.59	0.62
E_{10}	0.61	0.62	0.67	0.47	0.69	0.75
E_{50}	0.38	0.37	0.41	0.31	0.41	0.39
E_{MAX}	0.75	0.72	0.80	0.55	0.79	0.89

1. *Iago omanensis* landings at Digha, West Bengal
2. *Leptomelanosoma indicum* landings at Digha, West Bengal
3. *Parastromateus niger* landings at Digha, West Bengal

Species	Nemipterus japonicus	Parastromateus niger	Pampus argenteus	Cynoglossus arel	Plicofilis layardi	Penaeus monodon
Catch	446.91 t	1296.88 t	4409.64 t	4577.52 t	4157.78 t	1214.58 t
Length range	63-297 mm	65-445 mm	70-305 mm	88-465 mm	120-445 mm	70-310 mm
Mode length	100 mm	155 mm	140 mm	240 mm	240 mm	230 mm
Lm50	145 mm	233 mm	249 mm	190 mm	330 mm	180 mm
Fecundity	47280	56809	60445	77805	237	171086-256228
LC50	96 mm	202 mm	115 mm	198 mm	168 mm	205 mm
L∞	313 mm	462 mm	315 mm	483 mm	462 mm	315 mm
K	0.54 y-1	0.58 y-1	0.62 y-1	0.42 y-1	0.42 y-1	1.6 y-1
TMAX	5.54 y-1	5.16 y-1	4.83 y-1	7.13 y-1	7.09 y-1	1.87 y-1
M	0.83 y-1	0.89 y-1	0.95 y-1	0.65 y-1	0.65 y-1	2.46 y-1
F	1.24 y-1	1.68 y-1	1.25 y-1	0.78 y-1	0.54 y-1	3.33 y-1
Z	2.07 y-1	2.57 y-1	2.20 y-1	1.43 y-1	1.19 y-1	5.79 y-1
E	0.60	0.65	0.57	0.55	0.45	0.58
E10	0.40	0.56	0.46	0.46	0.47	0.62
E50	0.31	0.34	0.32	0.30	0.32	0.39
EMAX	0.52	0.65	0.57	0.60	0.57	0.75

Species	*Solenocera crassicornis*	*Penaeus semisulcatus*	*Parapenaeopsis stylifera*	*Parapenaeopsis sculptilis*
Catch	981.20 T	830.78 T	1625.35 T	1097.65 T
Length range	45-125 mm	101-242 mm	55-130 mm	63-180 mm
Mode length	100 mm	180 mm	100 mm	145 mm
Lm_{50}	80 mm	145 mm	75 mm	100 mm
Fecundity	4000-85876	283813-668076	50737-429000	51,907-306400
Lc_{50}	90 mm	161 mm	98 mm	129 mm
L_{∞}	129 mm	262.5 mm	133.8 mm	183.8 mm
K	1.7 y^{-1}	1.6 y^{-1}	1.7 y^{-1}	1.7 y^{-1}
T_{MAX}	1.76 y^{-1}	1.87 y^{-1}	1.76 y^{-1}	1.76 y^{-1}
M	2.61 y^{-1}	2.46 y^{-1}	2.61 y^{-1}	2.61 y^{-1}
F	2.87 y^{-1}	2.62 y^{-1}	5.99 y^{-1}	3.11 y^{-1}
Z	5.48 y^{-1}	5.08 y^{-1}	8.60 y^{-1}	5.72 y^{-1}
E	0.52	0.52	0.70	0.54
E_{10}	0.66	0.66	0.70	0.67
E_{50}	0.41	0.39	0.42	0.40
E_{MAX}	0.80	0.80	0.80	0.80


1.

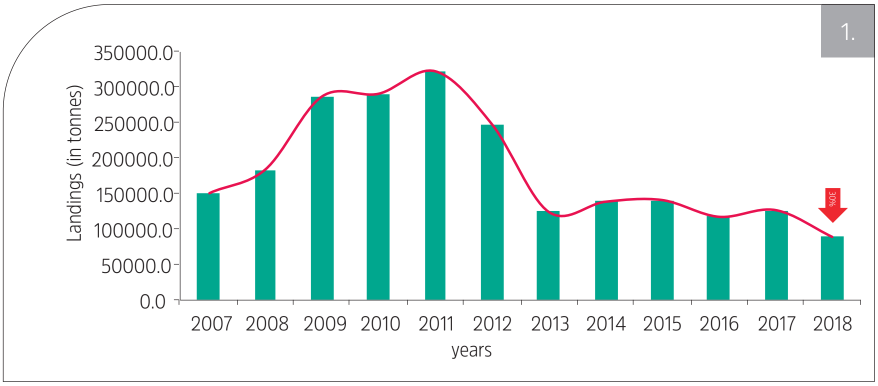
Change in the landings of major pelagic groups in 2018 compared to 2017

Pelagic resources	Landings (t)		% change
	2018	2017	
Lesser sardine *Sardinella fimbiata*, *Sadinella* spp.	16253.5	13260.6	22.6
Indian mackerel *Rastrelliger kanagurta*	12364.5	7602.9	62.6
Ribbonfishes *Trichiurus lepturus, T. ganegeticus, Lepturacanthus savala, Eupleurogrammus muticus*	5929.2	10501.9	-43.5
Hilsa shad *Tenualosa ilisha*	3889.6	4529.3	-14.1
Other anchovies *Stolephorus indicus, S. commersonnii, Thryssa mystax, T. setirostris, T. malabarica, T. hamiltoni, T. kammalensis, T. kammalensoides, T. dussumieri, Setipinna phasa, S. tenuifilis*	3486.4	6689.705	-47.9
Bombayduck *Harpadon nehereus*	3136.9	2387.7	31.4
Ilisha *Ilisha megaloptera, I. elongate, I. melastoma, Ilisha* spp.	2615.4	3944.6	-33.7
Coilia *Coilia dussumieri, C. ramcarati*	2330.2	3946.2	-41.0
Seerfish *Scomberomorus guttatus, S. commerson*	1840.7	2024.4	-9.1
Other carangids *Alectis indica, A. ciliaris, Alepes djedaba, A. kleinii, A. melanoptera,Atropus atropos, Atule mate, Trachinotus spp., Selar crumenophthalmus, Caranx sexfasciatus, C. ignobiolis, Carangoides talamparoides*	1567.7	2738.9	-42.8
White sardine *Escualosa thoracata*	1545.8	1166.4	32.5
Horse mackerel *Megalaspis cordyla*	1209.0	4076.4	-70.3
Mullet *Mugil cephalus, Chelon parsia, Valamugil* spp.	1136.1	1011.6	12.3
Wolf-herring *Chirocentrus dorab, C. nudus*	454.3	754.0	-39.7
Leather-jacket *Scomberoides commersonnianus, S. tol*	372.2	1248.7	-70.2
Tardoore *Opisthopterus tardoore*	296.0	1091.1	-72.9
Halfbeak and fullbeak *Ablennes hians, Strongylura strongylura, S. leiura, Tylosurus crocodilus, Hemiramphus archipelagicus, Hyporhamphus limbatus, Rhynchorhamphus* spp.	259.9	254.4	2.2
Indian oil sardine *Sardinella longiceps*	228.9	226.5	1.1
Rainbow sardine *Dussumieria acuta*	214.8	57.7	272.3
Other shad *Hilsa kelee*	185.8	738.5	-74.8
Scad *Decapterus russelli, Decapterus* spp.	142.6	24.3	486.8
Barracuda *Sphyraena putnamae, S. jello, S. obtusata*	117.0	316.24	-63.0
Tuna *Euthynnus affinis*	74.0	310.9	-76.2
Gizzard shad *Anodontostoma chacunda*	68.1	599.6	-88.6
Cobia *Rachycentron canadum*	53.0	54.8	-3.3
Billfish *Istiophorus platypterus*	17.9	5.0	258.0
Dolphinfish *Coryphaena hippurus*	7.5	2.0	275.0

1. Shrimp landings at Digha
2. *Escualosa thoracata* landings at Antharbanki landing centre

groups in 2018 compared to 2017

Demersal resources	Landings (t)		% change
	2018	2017	
Croaker *Johnius carutta, Johnius spp.,Kathala axillaris, Otolithoides biauritus, Otolithes ruber, Nibea maculate, Protonibea diacanthus, Pennahia anea, Panna microdon, Daysciaena albid, Chrysochir aureus, Pterotolithus maculatus*	8292.7	14112.7	-41.2
Pomfret *Pampus argenteus, P. chinensis, Parastromateus niger*	2912.8	6056.1	-51.9
Catfish *Plicofollis dussumieri, P. tenuispinis, Netuma thalassina, N. bilineata, Osteogeneiosus militaris, Plotosus canius*	2859.7	4484.9	-36.2
Soles *Cynoglossus arel, C. lingua, C. dubius, C. macrostomus, Cynoglossus* spp.	1484.1	1586.3	-6.4
Eel *Muraenesox bagio, congresox talabonoides, Strophidon sathete*	560.7	1457.9	-61.5
Sillago *Sillago sihama, S. vincenti, Sillago* spp., *Sillaginopsis panijus*	486.5	348.7	39.5
Goatfish *Upeneus sulphurous, U. supravittatus*	437.2	809.2	-46.0
Threadfin *Eleutheronema tetradactylum, Leptomelanosoma indicum, Polynemus paradiseus, Polydactylus sextarius*	379.6	404.3	-6.1
Pufferfish *Lagocephalus inermis, L. lunaris, L. spadiceus, Takifugu oblongus*	372.3	399.7	-6.9
Silverbellies *Eubleekeria splendens, Gazza achlamys, Karalla daura, K. dussumieri, Leiognathus equulus, L. brevirostris, Photopectoralis bindus, Secutor insidiator, S. ruconius*	334.6	1210.7	-72.4
Tigerperch *Terapon jarbua, T. theraps*	257.3	706.5	-63.6
Seabream *Rhabdosargus sarba, Acanthopagrus berda*	210.8	142.0	48.5
Grunts *Pomadasys kaakan, P. maculatus*	187.4	99.8	87.8
Threadfinbream *Nemipterus japonicus, N. randalli, N. bipunctatus*	186.9	1678.4	-88.9
Driftfish *Ariomma indicum*	173.6	148.8	16.7
Shark *Carcharhinus sorrah, C. amblyrhynchos, C. leucas, Chiloscyllium indicum, Rhizoprionodon oligolinx, Scoliodon laticaudus, Sphyrna lewini*	165.6	1045.0	-84.2
Grouper/Rockcod *Epinephelus coioides, E. latifasciatus, E. epistictus*	158.6	95.8	65.6
Ray *Gymnura poecilura, pateobatis bleekeri, P. gerradi, Himantura uarnak, pastinachus sephen, Rhinoptera javanica, Brevitrygon imbricate, Aetobatus* spp.	141.7	601.2	-76.4
Lizadfish *Saurida micropectralis, S. undosquamis*	124.7	160.1	-22.1
Snapper *Lutjanus johnii, L. argentimaculatus, L. rivulatus, Lutjanus* spp.	89.9	576.0	-84.4
Flatheads *Platycephalus indicus, Platycephalus* spp., *Grammoplites scaber*	67.9	215.3	-68.5
Barramundi *Lates calcarifer*	59.5	9.2	546.7
Priacanthus *Priacanthus hamrur*	49.9	240.7	-79.3

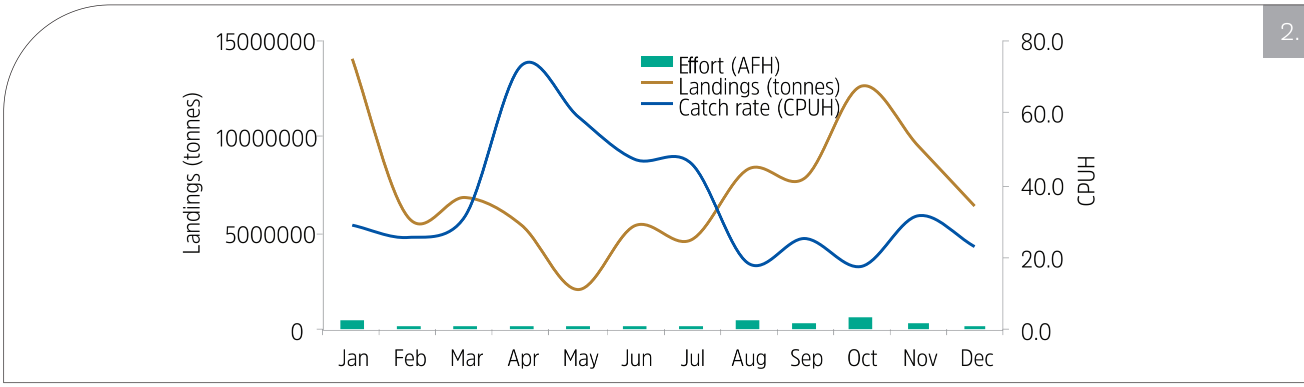


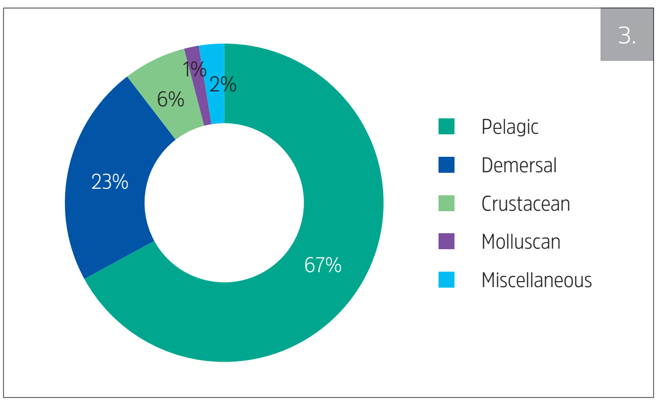
Gear-wise contribution to the total marine fish landings of Odisha coast in 2018

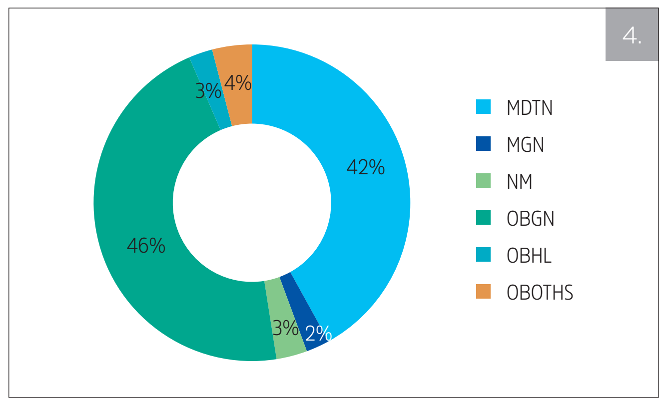
Gear	MDTN	MGN	NM	OBGN	OBHL	OTHRS	Total
Catch (t)	37426.0	2136.5	2810.6	41025.8	2167.0	3611.7	89177.5
% contribution	42.0	2.4	3.2	46.0	2.4	4.0	100

Length range, mean length and sex ratio of important resources studied during the year 2018

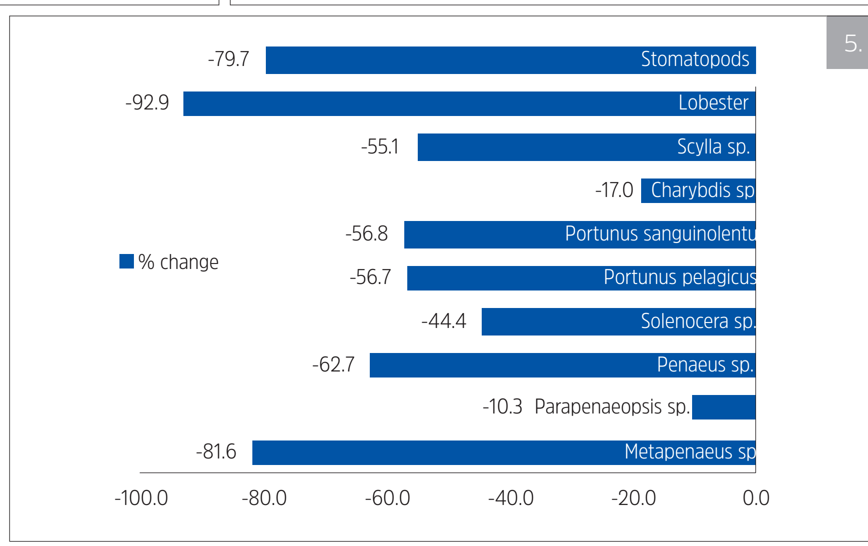
Species	Sample size (n)	Length range (cm)	Mean length (cm)	Sex ratio (M:F)	Maturity (%)
Sillago vincenti	195	10.7-35.0	22.8	0.61	65
Sillago sihama	208	3.7-23.4	16.2	1.01	77
Iago omanensis	149	13.3-68.2	38.2	0.13	85
Scoliodon laticaudus	103	22.2-51.5	34.2	0.66	20
Gymnura poecilura	71	22.1-73.1	38.9	0.92	32
Otolithes ruber	109	15.7-49.0	26.9	0.89	37
Plicofollis tenuispinis (P. layardii)	86	22.2-49.5	33.8	0.58	27
Plicofollis dussumieri	59	24.9-59.1	42.1	0.78	5
Rhabdosargus sarba	109	9.0-49.6	20.7	1.25	58
Trichiurus lepturus	154	16.9-42.0	24.2	0.88	45
Megalaspis cordyla	169	14.8-42	26.3	0.93	31.4
Ilisha megaloptera	143	12.0-33.5	22.8	0.33	19
Sepiella inermis	482	2.9-7.8	5.56	0.92	43.3
Sepia pharaonis	176	8.1-30.0	18.7	1.02	46.0
Uroteuthes (P.) duvaucelli	944	3.3-20.6	9.0	1.30	41.2
Sepia aculeata	151	4.6-19.7	13.0	0.72	49.0
Portunus sanguinolentus	332	4.5-16.8	11.9	0.90	74.0
Portunus pelagicus	186	4.7-18.7	13.7	1.04	73.5
Charybdis feriata	88	5.5-13.2	9.7	0.91	77.9
Parapenaeopsis stylifera	301	6.7-12.9	9.9	0.47	55.2
Metapenaeus monoceros	121	8.9-19.2	13.1	0.41	34.2
Solenocera crassicornis	460	6.0-12.7	9.02	0.49	61.0
Metapenaeus affinis	229	7.8-20.3	13.0	1.06	70.0

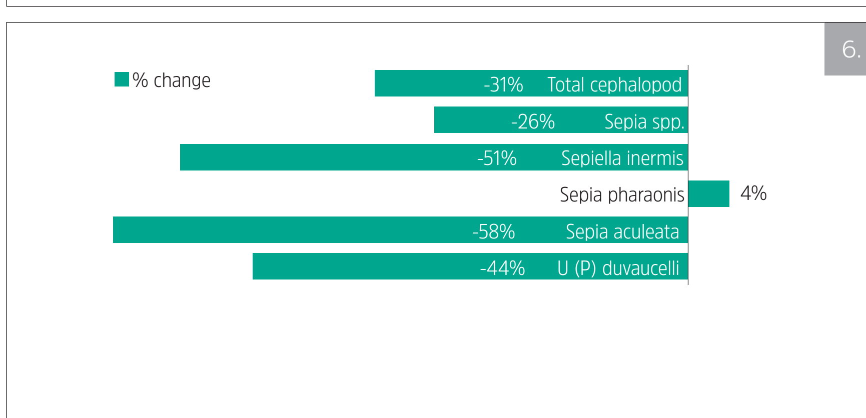






1. Marine fish catch trend of Odisha coast during 2007-2018
2. Monthly distribution of catch, effort (AFH) and catch rate (CPUH) of Odisha coast
3. Group wise contribution to the total marine fish landings of Odisha coast in 2018
4. Changes in the landings of major crustaceans in 2018 compared to 2017
5. Changes in the landings of major cephalopods in 2018 compared to 2017
6. Gear-wise contribution to the total marine fish landings of Odisha coast in 2018





1. Catfish landings at Pentakota landing cetre, Puri
2. *Rhabdosargus sarga* landings at Chandrabhanga fish landing centre, Puri
3. *Tenuolosa ilisha* landings at Bhabalpur fish Landing centre, Balasore

and skates showed tremendous increase of 350 and 159% respectively compared to previous year.

Crustacean resources: With an annual landing of about 22,000 t, crustacean fishery resources contributed nearly 14% to the total marine fish landings. Major resources were penaeid shrimps (13508 t), followed by non-penaeid shrimps (4545 t), crabs (4063 t) and lobsters (103 t). Penaeid shrimps were represented by *Parapenaeopsis* spp. such as *P. stylifera, P. sculptilis, P. hardwickii* and *P. uncta* contributing 4781 t followed by *Metapenaeus* spp. like *M. monoceros, M. brevicornis* and *M. affinis* forming 4322 t; *Penaeus* spp. like *P. indicus, P. monodon, P. semisulcatus, P. japonicus* contributing 3346 t; *Solenocera* spp.–*S. hexti, S. crassicornis* contributing 981 t and *Metapenaeopsis stridulans* contributing 78 t. Non-penaeid shrimps were represented by *Acetes indicus* forming 2667 t followed by *Plesionika* sp. (1856 t). Crabs were mainly *Portunus sanguinolentus* and *P. pelagicus* together contributing 3426 t followed by *Charybdis feriatus* (221 t). *Panulirus homarus* (64 t) and *P. polyphagus* (1 t) formed the lobster landings. Most of the crustacean resources showed decreasing trend in their landings except for *Metapenaeopsis stridulans, Acetes indicus* and crabs.

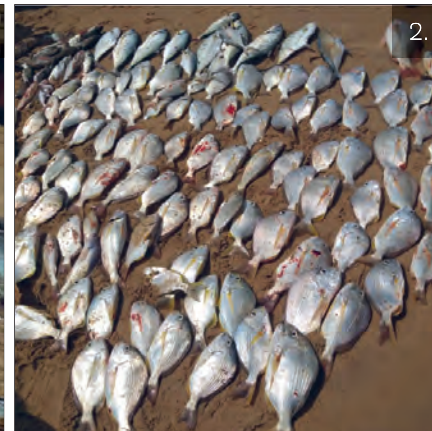
Molluscan resources: Molluscan fishery resources contributed nearly 2% (2.7 thousand t) of the total marine fish landings of West Bengal. The major resources under this group were *Uroteuthis (Photololigo) duvaucelii, Sepia aculeata, Sepia pharaonis* and *Sepiella inermis*. The landings decreased by about 41% compared to the previous year.

Gearwise contribution: Maximum landings was from mechanized multiday trawlers (50%) followed by mechanized bagnetters (20%), mechanized gillnetters (18%) and in-board bagnetters (8%). Minor contribution was also made by in-board gillnetters (2%) and other type of fishing gears (2%).

Biology: Growth parameters (L_∞, K and t_0), mortality and exploitation parameters (M, F, Z and E) and reproductive biology parameters (fecundity, age/length at maturity and food and feeding habits) were estimated for selected commercially important marine species of the state

Odisha

The total marine landings of Odisha coast during 2018 was estimated at 89177.5 t registering a decline of about 30% compared to the previous year (126958.2 t). Analysis of twelve year landings from 2007 to 2018 revealed the highest catch of 322683.8 t in 2011 followed by gradual decline and lowest during the current year. This may be due to the reduction in fishing days due to natural calamities like low pressure/ cyclonic events. Monthly catch analysis of 2018 indicated that the fishery attained peak during the first quarter of the year registering highest catch in January, after which the catch declined gradually with the lowest catch in May due to the monsoon fishing ban period. The fishery again revived during the last quarter of the year i.e. post ban period which is a general characteristic for Indian marine fisheries. However, lowest catch rate (CPUH) was observed during first and last quarter of the year and highest in monsoon fishing ban period i.e. April and May. Though the catch decreased during the ban period, catch rate (CPUH) from the traditional fishing crafts and gears maximized during the period. Group wise analysis in 2018 indicated highest catch by pelagic (59797.2 t) followed by demersal (20083.5 t), crustacean (5683.2 t),



molluscan (1334.6 t) and miscellaneous (2279.0 t) fishery resources.

Pelagic resources: The annual landings of pelagic fishery resources were estimated at 59797.2 t (67%) during 2018. Major resources were lesser sardine (16253.5 t), Indian mackerel (12364.5 t), ribbonfish (5929.2 t), hilsa shad (3889.6 t), anchovies (3486.4 t), Bombayduck (3136.9 t), ilisha (2615.4 t), coilia (2330.2 t), seerfish (1840.7 t), other carangids (1567.7 t), white sardine (1545.8 t), horse-mackerel (1209.0 t), mullet (1136.1 t), wolf-herring (454.3 t), leatherjacket (372.2 t), tardoore (296.0 t), halfbeak and fullbeak (259.9 t), Indian oil sardine (228.9 t), rainbow sardine (214.8 t) and other shad (185.8 t). Catch of lesser sardine, Indian mackerel, Bombayduck, white sardine, mullet, halfbeak and fullbeak, Indian oil sardine, rainbow sardine, scad, billfish and dolphinfish increased whereas ribbonfish, hilsa shad, anchovies, ilisha, coilia, seerfish, other carangids, horse mackerel, wolf-herring, leatherjacket, other shad, barracuda, tuna, gizzard shad, cobia declined in 2018 in comparison with the previous year.

Demersal resources: The annual landings of demersal fishery resources were estimated at 20083.5 t (23%) of the total marine fish landings. Major resources were croaker (8292.7 t), pomfret (2912.8 t), catfish (2859.7 t), soles (1484.1 t), eel (560.7 t), sillago (486.5 t), goatfish (437.2 t), threadfin (379.6 t), pufferfish (372.3 t), silverbellies (334.6 t), tigerperch (257.3 t), seabream (210.8 t), grunts (187.4 t), threadfinbream (186.9 t), driftfish (173.6 t), shark (165.6 t), grouper/rockcod (158.6 t), ray (141.7 t), lizardfish (124.7 t), snapper (89.9 t) and flatheads (67.9 t). Most of the demersal resources showed tremendous decrease in their catch except for sillago, seabream, grunts, driftfish, grouper/rockcod and ray in 2018 in comparison to 2017.

Crustacean resources: Crustacean fishery resources contributed nearly 6% (5.6 thousand t) to the total marine fish landings. Major resources were penaeid shrimps (3861.9 t), followed by crabs (1818.2 t), lobsters (2.6 t) and stomatopods (0.5 t). Penaeid shrimps were represented by *Parapenaeopsis* spp. such as *P. stylifera, P. sculptilis, P. hardwickii, P. uncta, P. maxillipido* forming 2152 t followed by genus *Metapenaeus–M. monoceros, M. brevicornis* and *M. dobsonii*

1. Cephalopod landings at Paradeep Fishing Harbour, Jagatsinghpur
2. Shrimp landings at Paradeep Fishing Harbour, Jagatsinghpur

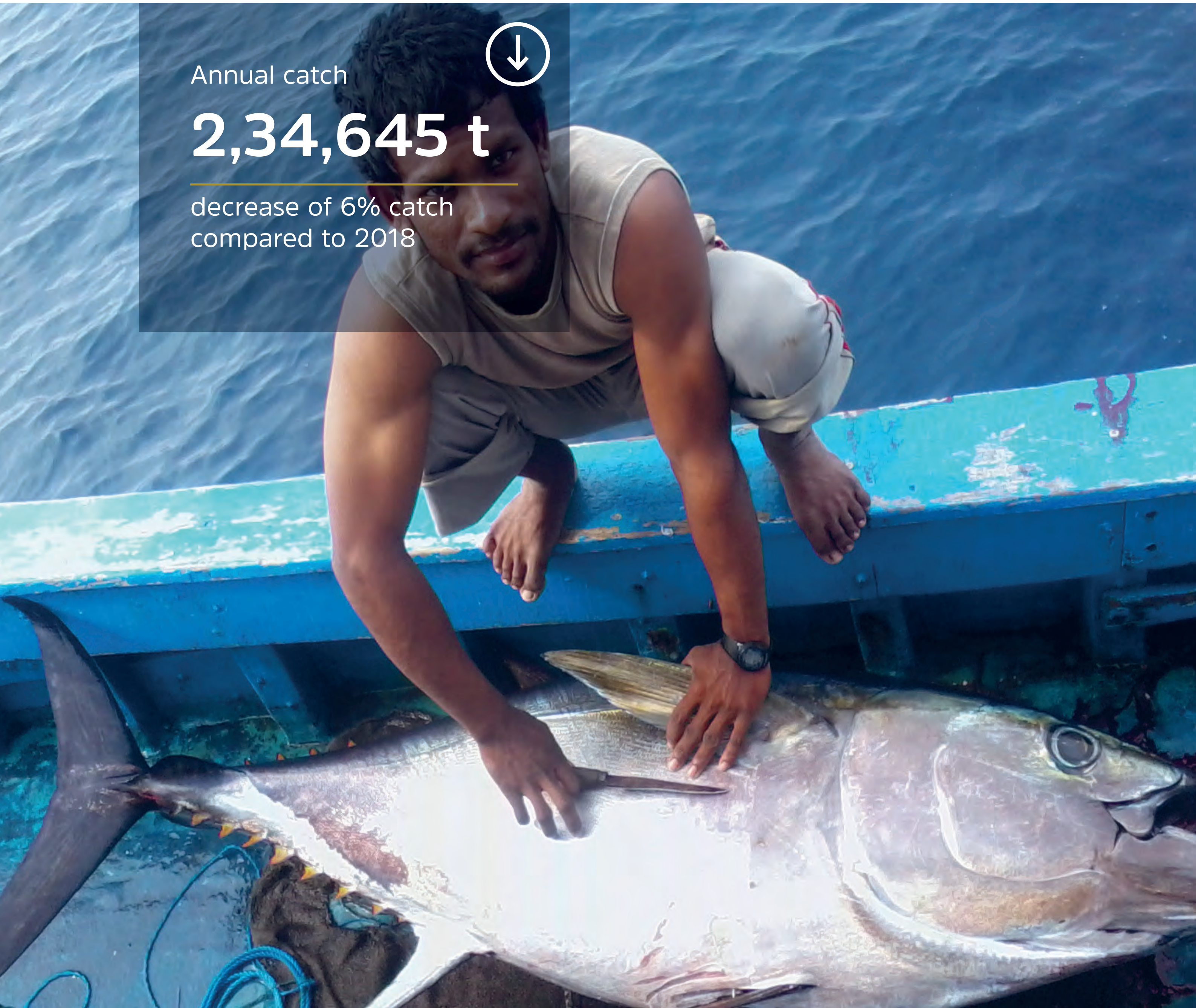
contributing 790 t; *Penaeus* group such as *P. indicus, P. monodon, P. semisulcatus, P. japonicus, P. merguensis* contributing 299 t; *Solenocera–S. hexti, S. crassicornis*–621 t. Crabs were constituted by *P. sanguinolentus* (965 t) and *P. pelagicus* contributing 304.4 t followed by *Charybdis sp.* which contributed about 519.7 t. Lobster landings were by *P. polyphagus* (2.3 t) with negligible contribution by *P. homarus* (0.1 t). Catch trend of all crustacean resources decreased compared to last year. Mechanized sector contributed highest (93%) followed by motorized (6%) and non-motorized of (1%) to the total landings of crustaceans in the current year and the highest landings was in October.

Molluscan resources: The annual landings of molluscan resources were 1.3 thousand t, forming 2% of the total marine fish landings. The major resources were *S. aculeata* (387.5 t), followed by *U. (P.) duvaucelii* (375.3 t) followed by *S. elliptica* (339.7 t), *S. pharaonis* (102.7 t), *S. inermis* (77.8 t) and other *Sepia* sp. (51.5 t). Cephalopod landings decreased by 31% compared to the previous year and lowest catch recorded since last ten years. Most of the cephalopod species revealed decreasing catch trend except for *S. pharaonis* where a minimal 4% increase in landings was observed from last year. In case of squids the total landings were by the single species *U. (P.) duvaucelii* with 44% decrease from last year. Multiday trawl was the single highest contributor to the cephalopod landings compared to other gears in 2018. January recorded highest landing of both squid and cuttlefish.

Gearwise contribution: Maximum catch was contributed by motorized gillnet (46%) and mechanized multiday trawlers (42%). A minor contribution was also made by non-mechanized gears (3.2%), mechanized gillnetters (2.4%) and motorized hook & line (2.4%).

Large Pelagics

Research project PEP/LPR/04



Large pelagic (LP) resources of the Indian waters are represented by tunas, seerfishes, barracudas, billfishes, mahi mahi, queenfishes, rainbow runner, kingfish and needlefishes. About 49 species belonging to different groups supported the fishery along the Indian EEZ.

Landing of large pelagics occurred throughout the mainland coast during the period. LP landing was dominated by tunas (46.3%) seerfishes (20%) and barracudas (14.5%). These groups represented more than 80% of the landing. Landing, however exhibited considerable spatial and temporal variations in the quantity and composition. Major share of the landing was realized during September-December and a small peak during March-April.

Trends in landing

The total LP landing was 234,645 t during 2019 and contributed 7.2% to the total national marine fish landing. However, during the current year it declined marginally to the tune of 6% compared to 2018. Among the component resources, landing of all resources except billfish, barracuda and Dolphinfish improved marginally.

Landing of co-existing resources: Target resources in the major gears (drift gillnets and hooks and lines) harvesting large pelagic varied with region and season. The major co-existing resources, which were landed along with LP vary with season and fishing ground. They were comprised mainly of sharks, rays, trevallies, etc.

Threatened and endangered fishes were not reported as by-catch in LP fishery along the Indian coast during the period.

Fishing methods: The large pelagic resources were principally tapped by the large meshed drift gillnets, a variety of hooks and lines, single day and multiday trawls and to a limited extend by different types of seine nets, bagnets and other non-mechanised gears. Basically several variants of these gears are operating along the Indian coast and named differently. Fishing duration also extended from few days to several weeks.

Major share of the landing was by gillnets along the mainland coast, which contributed nearly 39% of the resource landed. It was followed by trawls (25.8%) and hooks and lines (18.4%). Along the Lakshadweep coast,

1. Gillnet fleet of Veraval coast Gujarat
2. Group wise representation in LP landing along the mainland coast
3. Large pelagic contribution by different gears
4. Landing trend of major LP resources over the year

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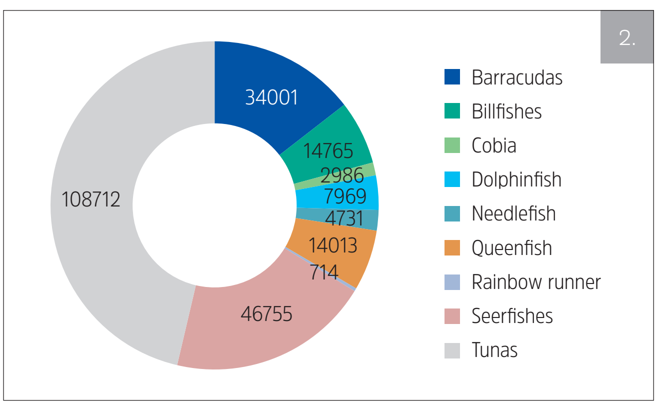
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Billfishes
Cobia
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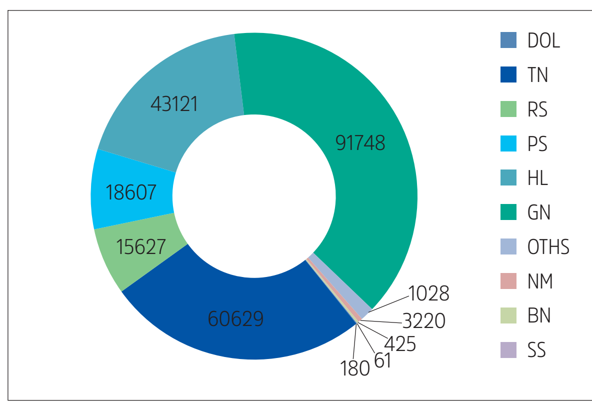
Needlefish
Queenfish
Rainbow runner
Seerfishes
Tunas

3.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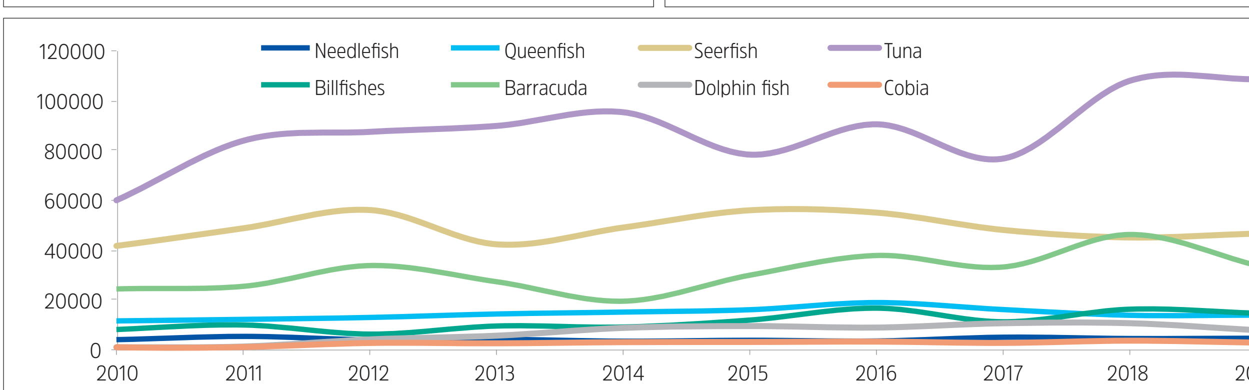
Needlefish
Queenfish
Seerfish
Tuna
Billfishes
Barracuda
Dolphin fish
Cobia
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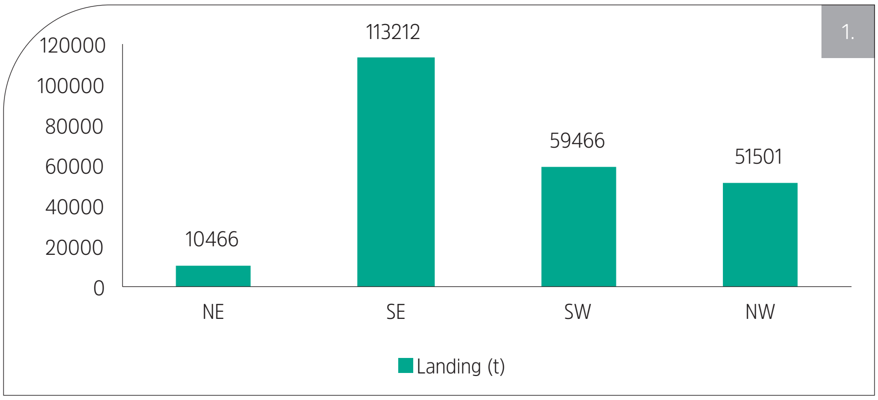


major share of the landing was by pole and lines, followed by hand lines and drift gillnets. Along the Andaman region it was mainly by drift gillnets.

Spatial landing pattern

Considerable variation could be seen in the LP composition, contribution to national landing, seasonal pattern along different areas. Major contributor to the total LP landing was Tamil Nadu, followed by Kerala and Gujarat. Major share of the tunas landed was from southeast coast and the lowest from northeast coast.

Biology: Interpretation of the biological data shows that mainly adult population constituted major part of the landing of most species, except King seer (*S. commerson)*, Cobia (*R. canadum)* large Barracuda (*S. jello)* and sword fish *(X. gladius)*, wheras juveniles form appreciable numbers, especially in the landing by gillnets. Prolonged spawning activity was observed in most species along the Indian coast with very specific peak spawning activity during which time massive spawning occurs.

Results of stock assessment of selected species at National level and their status of exploitation

Sl.No.	Species	F/F_{MSY}	B/B_{MSY}	SSB-%	Status of exploitation
1.	*Euthynnus. Affinis*	1.071	0.984	36	Subjected to marginal overfishing
2.	*Thunnus albacares*	0.867	1.22	48	Not subjected to overfishing
3.	*Scomberomores commerson*	1.090	0.963	29	Subjected to marginal overfishing
4.	*Coryphaena hippiurus*	0.842	1.28	53	Not subjected to overfishing

Results of stock assessment of selected species along the southwest coast and status of species exploitation

Species	Nat. mortality	Fish. mortality	Total mortality	Ecurr	Emax	Lc50 mm	Status of fishing
E. affinis	0.911	1.409	2.32	0.607	0.671	40.3	Under-fished
A. thazard	1.685	3.91	5.59	0.70	0.945	38.45	Under-fished
S. commerson	1.2894	2.82	4.11	0.69	0.638	79.4	Over-fished


2.


3.


4.

1. Region wise landing of large pelagics
2. Heavy landing of rays by LP fishing fleets at Tharuvaikkulam fish landing centre of Tamil Nadu
3. Longliner with yellowfin catch at Kochi fisheries harbour
4. A large heap of sailfish landed at Kochi fisheries harbour

Stock status: Stock assessment at national level indicated that the Yellowfin tuna (*Thunnus albacares) and* Mahi mahi *(Coryphaena hippurus)* were optimally harvested. Whereas Kawa kawa (*Euthynnus. Affinis) and narrow-barred Spanish mackerel*(*Scomberomorus commerson*) were subjected to marginal overfishing.

It is to be noted that mainly neritic species were subject to comparatively high harvest pressure and so had only limited scope for their enhanced production from the present fishing areas. Present fishing areas of coastal waters needs measures to minimize/ avoid over fishing including harvest of under sized fishes to enhance and sustain their production. Oceanic resources on the other hand is under-fished and had considerable scope for enhanced production from the present fishing grounds. Considerable scope is also there for enhancing production by extending fishing operations to other less fished areas like Andaman and Lakshadweep seas.

1. A fish trader carrying yellowfin tuna in motor bike, Kochi
2. Massmin preparation unit in Agatti Island, UT of Lakshadweep

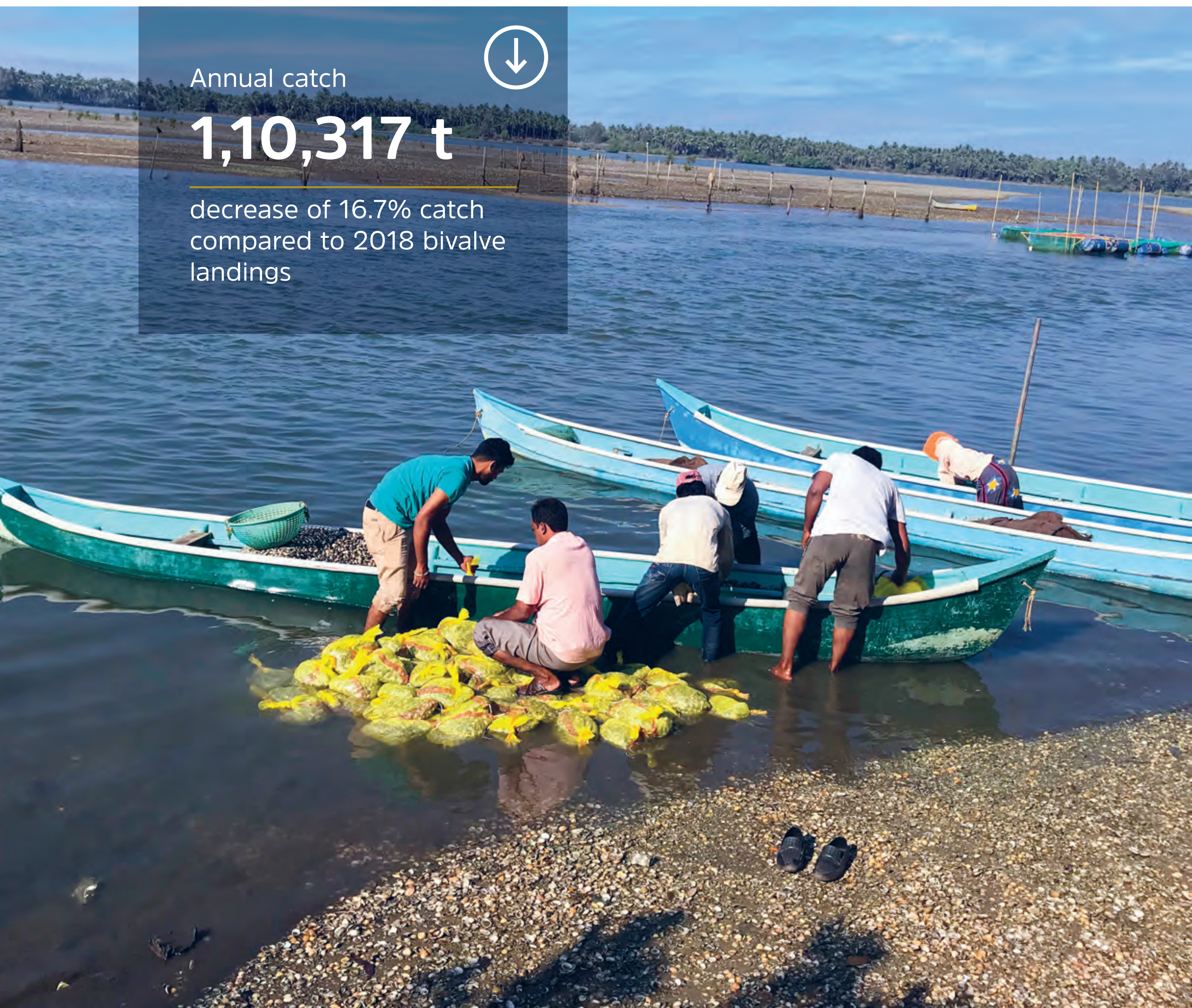
Taxonomic study: Morphological ambiguities were observed in species of seerfish. Hence a detailed taxonomic study was initiated during the year to address the issue.

Disposal and utilization of catch: Major share of the landing were sold for domestic consumption in the local markets of the states or send to other states. Of the several LP resources landed, only tunas and seerfishes were exported in different forms.

Bivalves

Research Project MFD/BIV/15

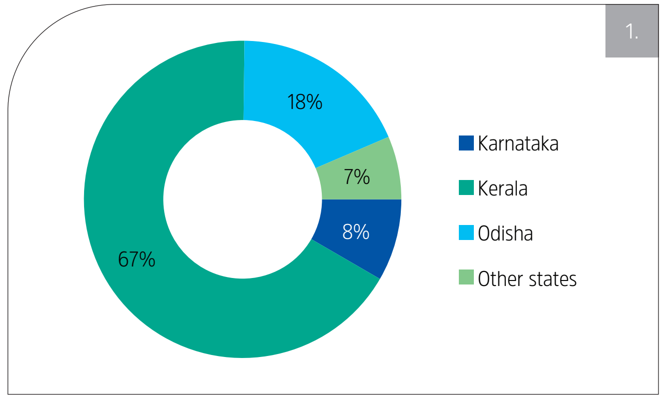
Transportation of clams to relaying areas in Coondapura Estuary, Karnataka

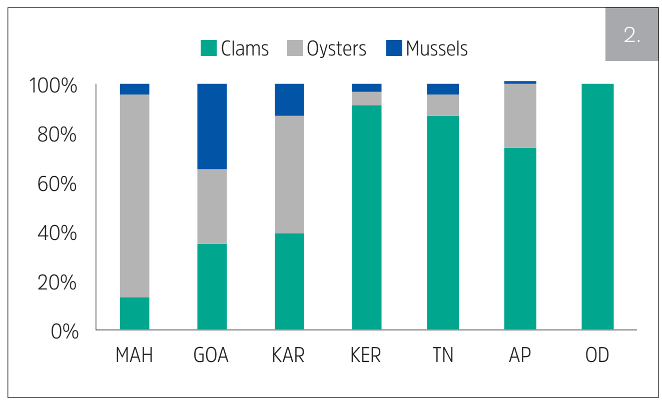


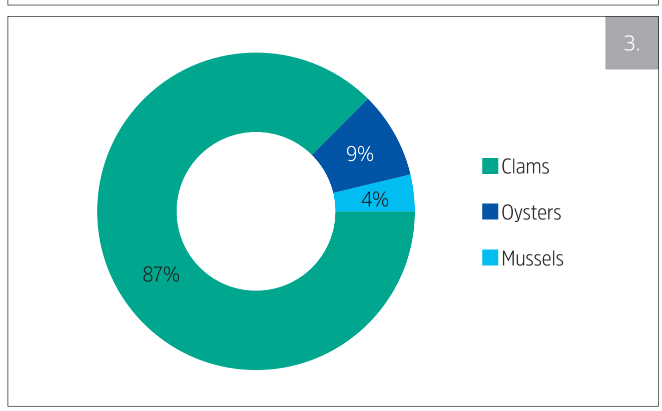
Annual catch

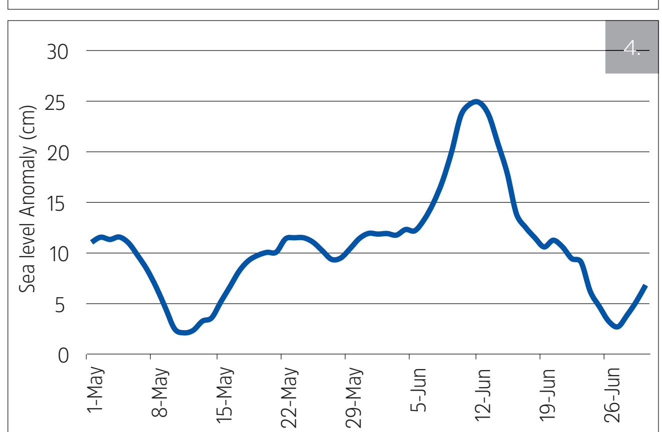
1,10,317 t

decrease of 16.7% catch compared to 2018 bivalve landings









Fishery Management Plans (FMPs) and recruitment dynamics of bivalves

The bivalve fishery from the major bivalve landing centres in Kerala, Karnataka, Goa, Maharashtra, Tamil Nadu, Andhra Pradesh and Odisha were monitored. The estimated catch of 110,317 tonnes recorded 16.7% reduction compared to 2018 (1,32,531 tonnes).

Kerala (66.8%), Odisha (18.4%) and Karnataka (8.4%) were the important bivalve producing States. Bivalve fishery was dominated by clams followed by oysters and mussels.

Maharashtra: Bivalve fishery of Maharashtra was dominated by oysters (82.26%) followed by clams (13.29%) and mussels (4.45%). The fishery was observed mainly from the coastal and estuarine waters of Sindhudurg and Ratnagiri Districts. Clam landing comprised of *Meretrix meretrix*, *M. casta*, *Paphia malabarica*, *Marcia opima* and others in the order of importance. Green mussels, *Perna viridis* was commercially exploited off Ratnagiri. The Indian rock oyster,

1. Contribution of Bivalve production by State in India
2. Contribution of clams, oysters and mussels by State
3. Contribution of clams, oysters and mussels to all India bivalve production
4. Sea level anomaly during mass mortality of *Mactra violacea* along Diveagar Beach, Maharashtra
5. Mass mortality of *Mactra violacea* along Diveagar Beach, Maharashtra


5.

Saccostrea cucullata, locally known as 'Kalva' contributed more than 90% to the oyster catch. Mostly women handpick the clams during low tide. Inter-state transportation of *Paphia malabarica* from Kerala, Goa to Ratnagiri and Mumbai market continued during the period.

Mass mortality of the venerid clam *Mactra violacea* was observed during the initial phase of monsoon, starting from 8 to 18 June 2019, along Diveagar Beach in Raigad District. Dead and moribund *M. violacea* individuals were spread over 1.5 km stretch of Diveagar Beach. Dead clam density of 82±13.65 per sq. m. was relatively higher than live clam density of 15±4.2 per sq. m. Biological investigation showed that almost all individuals were mature having male to female ratio of 1:0.59. Condition Index (CI) based on dry flesh weight and shell cavity volume ranged between 7.4 to 18.5. Altimeter satellite gridded data computed from all altimeters in the 5 sq.km. grid along Diveagar Beach during 01 May-30 June 2019 showed sudden rise in significant wave height from 13 cm to 25 cm. This sudden increase in wave height as well as periodic disturbance at sea bottom might have carried the clams towards the upper tidal zones exposing to desiccation, indicating a probabale reason for sudden mass mortality of *M. violacea.*

Karnataka: The bivalve production from the State decreased by 58% due to the poor mussel spat settlement in the intertidal and subtidal area during the post-monsoon period of 2019. *Crassostrea madrasensis* and *Meretrix casta* dominated the bivalve fishery. Clam and oyster production were estimated from major landing centres in Netravathi, Gurupura, Mulki, Udyavara, Swarna-Sita, Coondapura, Venkatapur, Sumana, Sharavathi, Aghanashini, Gangavali, Kali estuaries. Green mussel fishery monitored from the coastal waters covering Someshwara, Surathkal, Kaup, Malpe, Gangolli, Kanchi kodi, Trasi, Maravanthe, Kirimanjeshwara, Karkikale, Madikal, Uppunda, Dhombae, Shiroor, Bhatkal, Jali, Murudeshwara, Kirubele, Tadri, Belekan and Majali decreased by 92% compared to 2018. During January-March, mussel fishery was observed for few days during low tide periods near the bar mouths of Netravathi, Gurupura, Swarna-Sita and Sumana Estuaries in Karnataka. Interstate transportation of clams from estuaries of Kerala, Tamil Nadu and Andhra Pradesh was observed.

Tamil Nadu: Bivalve production from Tamil Nadu and Pondicherry recorded three-fold increase compared to 2018. Nearly 90% of the production was contributed by clams. Increased in clam fishing effort was due to the increased demand in Kerala, Karnataka, Goa and Maharashtra. *M. casta*, *Donax* sp. and *C. madrasensis* were the dominant bivalve species. Analysis of stock status of *M. casta* from Pazhayakayal Estuary indicated overexploitation. *M. casta* in the size range of 14 to 49 mm were exploited in the Chunnambar Estuary, Puducherry, indicating exploitation of small sized clams. The

peak spawning season was during August to December.

Andhra Pradesh: Bivalve landings from Kakinada Bay and Bheemli Estuary were monitored. *M. meretrix*, *Tegillarca* (*Anadara*) sp., *Marcia opima* and *C. madrasensis* dominated the fishery. There was live export of *Anadara* sp. from Kakinada to Singapore and Malaysia through Chennai and West Bengal. Illegal collection of *Placuna placenta* was completely stopped due to strict surveillance by the forest department. In Bheemli, peak spawning season of *M. meretrix* was observed during March-April and August-October, and spat fall during May-June and December-January. The *C. madrasensis* spatfall was recorded during October-January and June.

Odisha: Bivalve fishery of Subarnarekha Estuary and Chilka Lake were monitored. The clam density in Subarnarekha Estuary varied between 1.7 to 4.0 kg/ sq.m with 43-120 nos./ sq.m. Annual salinity variation was 5 to 17 psu during different months. *Meretrix meretrix* dominated the fishery followed by *Tegillarca* (*Anadara*) sp. in both the estuaries. *M. meretrix* was exploited exclusively for shells. Considering the domestic demand for clams in the southern states, the possibility of inter-state transportation and marketing is a possible option for utilizing the clam meat with the involvement of various stakeholders

Kerala: The state contributed 66.8% to the total estimated bivalve production. Clams dominated the bivalve fishery followed by edible oysters and mussels. Black clam, *Villorita cyprinoides* was the most important clam species exploited in India (55%), with Kerala contributing to more than 90% to the fishery. Black clam catch rate in Vembanad Lake decreased from 321 kg/unit in 2018 to 204 kg/unit in 2019, resulting in 15% reduction in the clam production. In spite of the recommendations from the Government, the juvenile clam exploitation continued for meeting the demand in the shell

1. *Meretrix casta* catch from Mulki Estuary, Karnataka
2. Clam fishery in Mulki Estuary, Karnataka
3. Sorting clams in Coondapura Estuary, Karnataka
4. Mussel fishery in Chettuva Estuary
5. Clam fishery in Ashtamudi Lake


4.


5.

and poultry industries. Juvenile black clams (<20mm) formed 6.8% of the catch from Vembanad Lake. In north Kerala, three-fold increase in black clam production was recorded, mainly from Kavvayi and Perumba of Kannur District

Paphia malabarica fishery recorded from Valapattanam, Korapuzha, Ponnani, Kayamkulam Kayal, Ashtamudi and Muthala Pozhi marginally decreased by 5% during 2019. Occurrence of microplastics was frequently recorded in the clam tissue collected from the Muthala Pozhi. The incidence was observed during the monsoon and post-monsoon months, associated with heavy land run-off. Catch and catch rate of *P. malabarica* from Ashtamudi Estuary decreased by 28.6% and 25% respectively. The dominant size ranges in the fishery was 27.3-35.4 mm and mean sizes were above MLS of 20 mm.

Crassostrea madrasensis fishery decreased by 17%. It was observed mainly from Kavvayi, Chaliyar and Korapuzha.

Green mussel landings in Kerala decreased by 49% due to poor spat settlement. Catch of brown mussel, *Perna indica* from Vizhinjam-Kovalam recorded marginal increase by 13.5%.

Peak fishing season was during September-December. Spatfall began by July and extended till September. Self-imposed fishing ban on collection of small brown mussels imposed by local mussel fishers continued along the coast for resource conservation.

Ashtamudi Clam Fisheries Management

The annual fishing ban in Ashtamudi continued during December-February. Since clam biomass survey undertaken in Ashtamudi Lake revealed that the stock was below the LRP of 6,000 t, adaptive management measures were recommended by CMFRI.

The 20-member Ashtamudi Lake Clam Fisheries Governance Council (ACFGC) met twice and decided on the following:

1. Number of fishing days reduced from 6 days per week to 5 days
2. Registration of the fishing boats engaged in clam fishery
3. Licensing of fishermen and issuance of identity cards
4. Enforcement of strict surveillance for conservation of juvenile clams
5. Measures for immediate removal of sandbars by dredging

1. *Mytella strigata* in oyster farm in Kerala
2. *Mytella strigata* collected from Ashtamudi Lake

Emergence of invasive mussel *Mytella strigata* in Kerala Backwaters

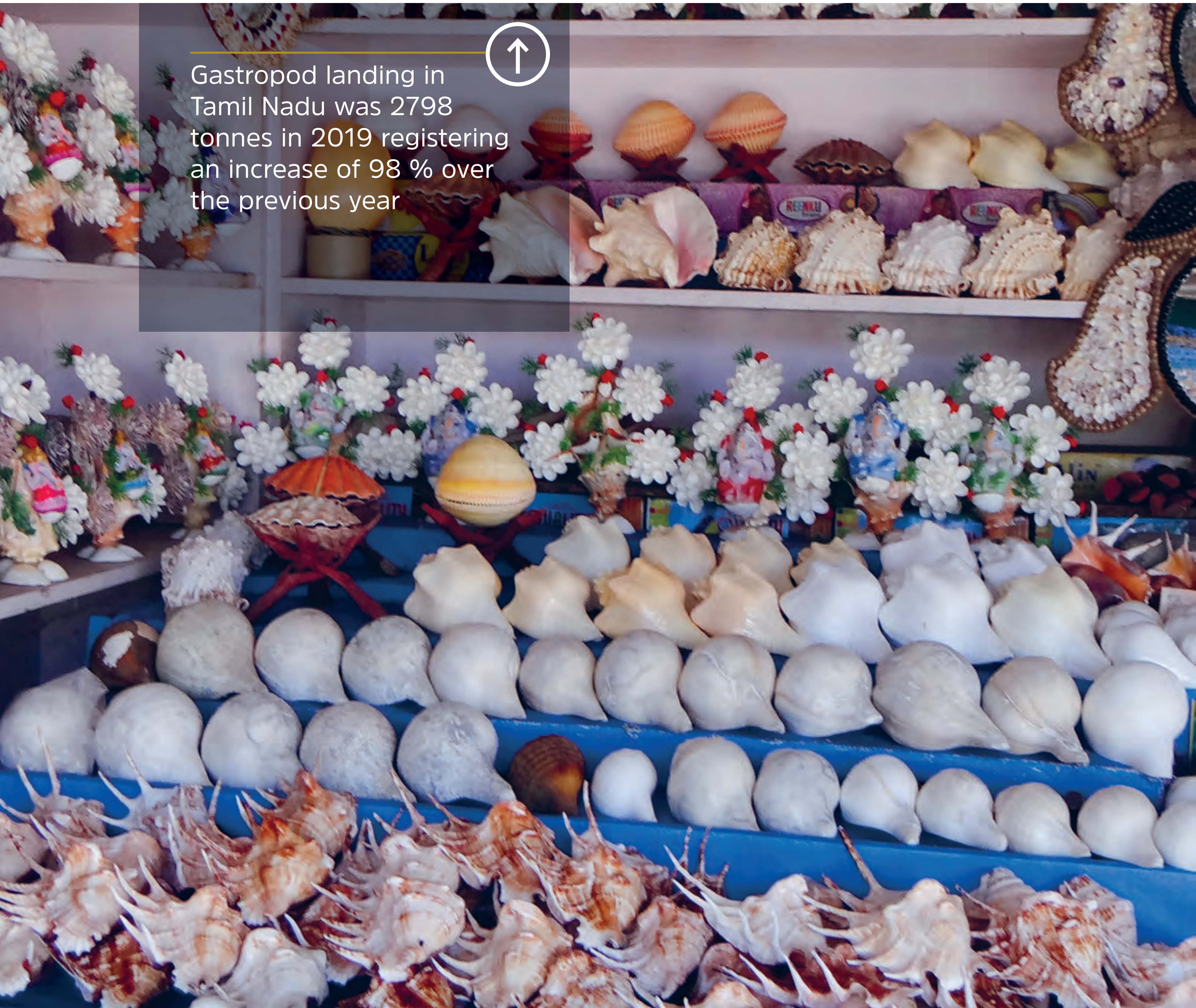
A new invasive species of mussel, the American brackish-water mussel *Mytella strigata*, native to Central and South America has established from 2018 onwards in backwaters of Kerala, blocking nets in cage farms. This species was recently reported from the Philippines, Singapore and Thailand, where its population has expanded exponentially in the last two years. *Mytella strigata* has recently become widespread in parts of Ashtamudi, Kayamkulam and Vembanad Lakes with densities reaching 150 per m^2 in Ashtamudi Lake. It is a potential threat to lucrative bivalve aquaculture as they could outcompete native mussels. Mytilids typically have a high fecundity, rapid growth rate, are filter feeders and are tolerant of a wide range of environmental conditions, all attributes that make them ideal for aquaculture. However, these features also make them potential invasive species. *M. strigata* clearly fits into this category. It is reportedly tolerant of a wide range of salinities.

CMFRI's Advisory: In order to avoid further establishment of *M. strigata* in other water bodies, the Kerala State Fisheries officials were alerted by CMFRI to discourage farmers from using this species for farming. Appropriate instructions for fishing and physically harvesting the species and utilizing it as feed ingredients were recommended and published as a brochure.

Gastropods

Research Project MF/GAST/16

A view of shell crafts displayed for sale in the outlets



Gastropod landing in Tamil Nadu was 2798 tonnes in 2019 registering an increase of 98 % over the previous year

Andhra Pradesh

Total gastropod landings of Andhra Pradesh are approximately 736.76 tonnes, landed at Kakinada, Visakhapatnam and Kancheru. The major mode of exploitation is handpicking with the help of small scoop nets and drag nets using "*Shoe dhoni*, *Kakinada Nava* and *fibre teppa*" and the season is August to December when the crab fishery is prominent.

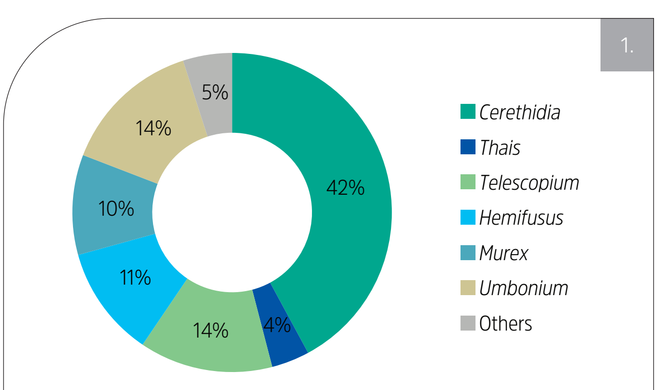
Kakinada

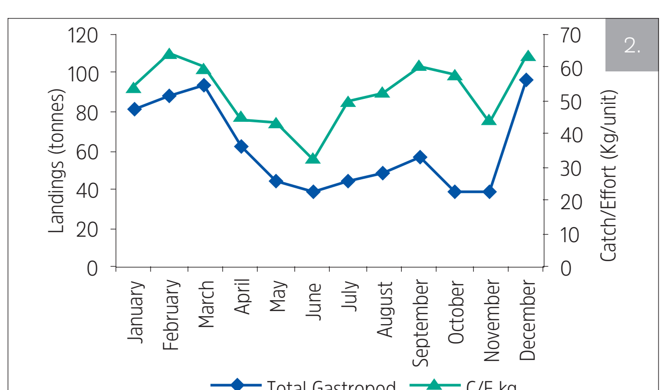
The total gastropod production from the Kakinada region was estimated at about 730.3 tonnes. There was an increase in catch of about 33.38% due to increase in landings of button shell and horn snails. The average effort was about 1157units with an average CPUE of 52.19 Kg/unit. The *Umbonium* sp. and *Cerethidia* sp. catch resumed due to demand from agents.

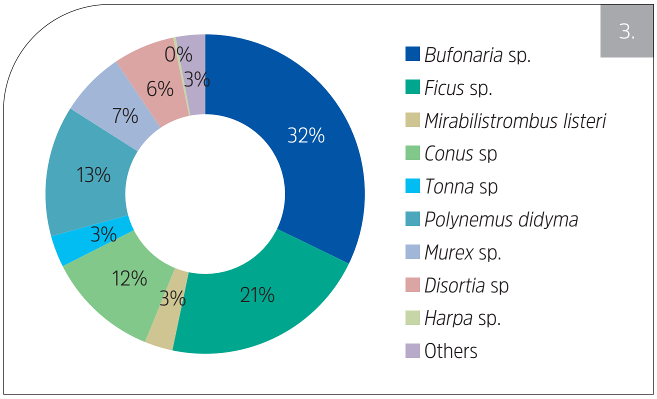
Visakhapatnam

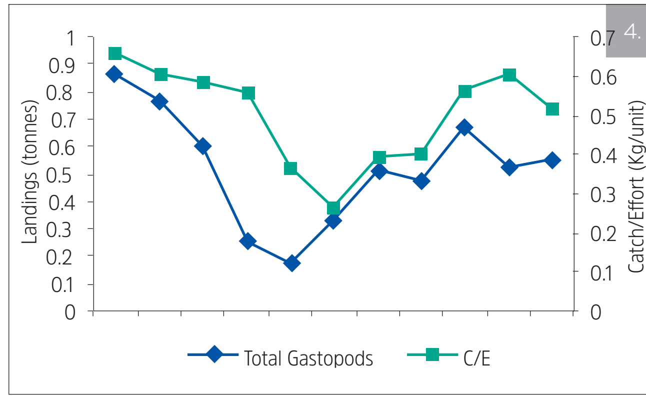
The total gastropod production from Visakhapatnam Fishing Harbour was about 5.715 tonnes. The average effort was about 1035 units with an average CPUE of 0.50 kg/unit. The major contributor in the trawl catch was *Bufonaria* spp. Four species of *Bufonaria* were observed in single day trawl catch. The *Bufonaria* sp. length ranged between 54 to 88 mm with an average of 69.65 mm. The MSD ranged between 30 mm to 51 mm with an average of 40.70 mm and the weight ranged between 20-45 g.

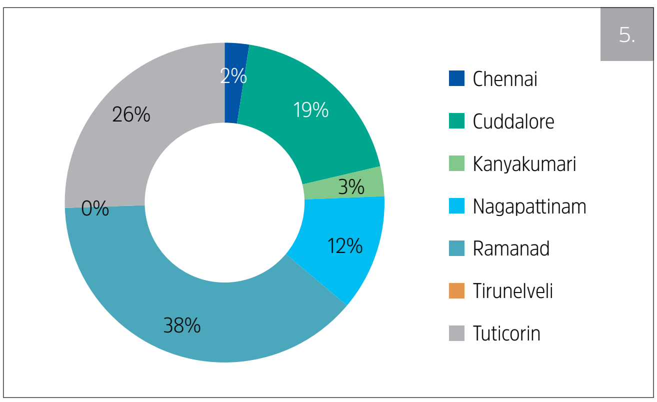
1. The percentage contribution of gastropod species in Kakinada
2. Month wise gastropod landing in Kakinada
3. The percentage contribution by different gastropods in Visakhapatnam
4. Month wise gastropods landing in Visakhapatnam
5. The percentage composition of gastropod catch from different District of Tamil Nadu
6. The percentage composition of gastropod catch by different gears –Tamil Nadu

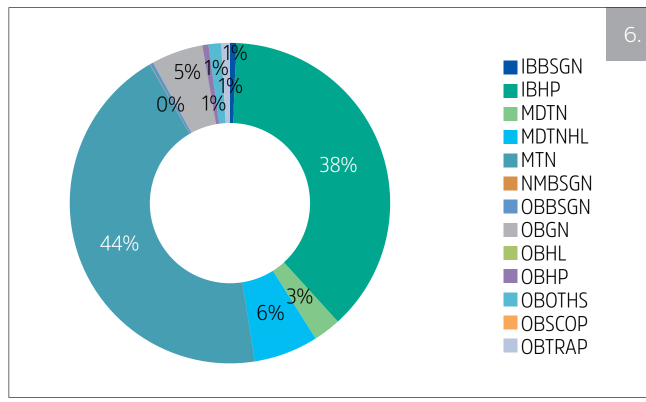












Kancheru

The total gastropod production from the Kancheru region was about 0.746 tonnes. The average effort was about 211 units with an average CPUE of 0.294 kg/unit. At Kancheru centre the major species contributing to the fishery were *Harpa major, Babylonia zeylanica, B. spirata, Murex* sp., *Hemifusus* sp. and others like *Oliva* sp., *Bursa* sp. etc.

Tamil Nadu

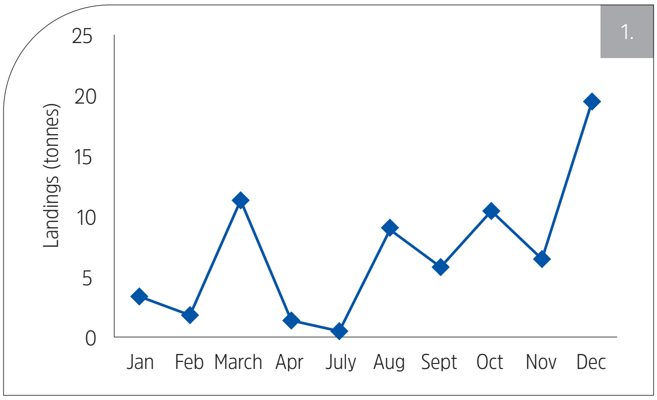
Gastropod landing in Tamil Nadu was 2798 tonnes in 2019 which is 98% increase compared to the previous year (1134 tonnes). Ramnad District contributes nearly 38% of the total catch followed by Tuticorin (26%), Cuddalore (19%), Nagapattinam (12%), Kanyakumari contributes 3% and Chennai (2%) and Tirunelveli contributes meagre catch. Among different gears, 44.1% of the catch is by MTN; 37.6 % of the catch is from Hand picking; MDTNHL contributes 6.5% of the catch; 5.2% is from OBGN and remaining by other gears.

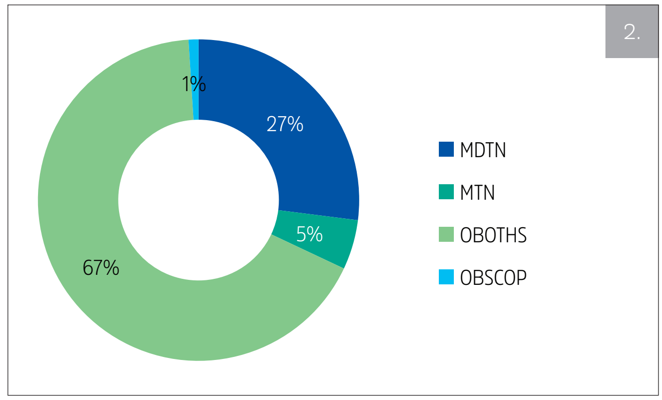
CPUE of Trawl Net: 0.8 kg/h; Gill Net: 6.5 kg/unit ; Skin Diving: 9.8 kg/person

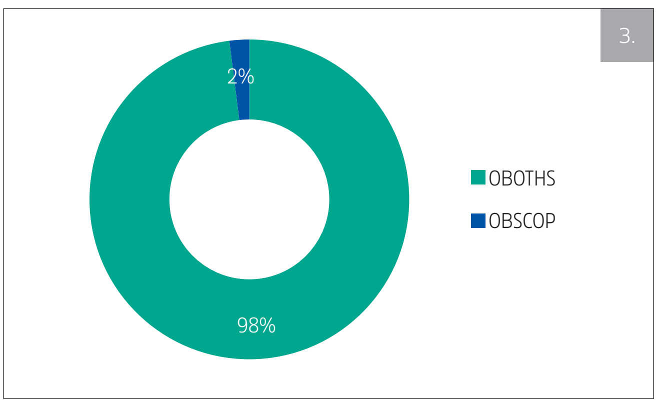
Chennai

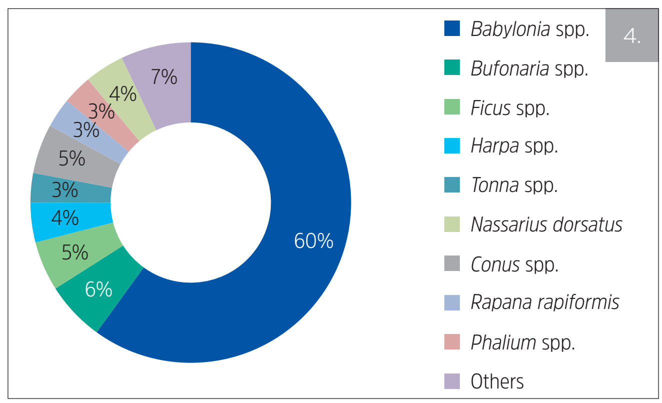
In Chennai Fisheries Harbour ornamental gastropods are mainly landed as by-catch along with other resources in the trawl landing. Total estimated landing of gastropods at Chennai Fisheries harbour was 65.84 tonnes. The fishery was comprised of about 30 species of gastropods. *Babylonia* sp. is the targeted fishery along the coast and it contributes about 68.24% to the total gastropod landings. There is a high export demand for *Babylonia* in the counties like China, Hongkong, Thailand. The other species which are regularly landed in the by catch were *Ficus spp., Bursa* spp., *Turittella* spp., *Tonna dolium, Nassarius dollium, Conus* spp., *Phalium* spp., *Rapana rapiformes.* Major share of landing of gastropods were contributed by multiday trawl net (58%).

Gastropods other than *Babylonia spp.*, are collected by some agents and the meat is separated from the shell and dried in









the sun. The assorted shells are separated species wise and sold to nearby Shell craft industry for further processing. In terms of percentage contribution landed *Babylonia* spp. contributed highest followed by *Bufonaria* spp., *Ficus* spp., *Harpa* sp., *Tonna* spp., *Nassarius dorsatus*, *Conus* sp., *Rapana rapifromis*, *Phalium* spp. and others.

Tuticorin

Gastropod landing in Tuticorin is 596.3 t. A total of 82% of gastropod catch is from diving and hand picking and 18% is from gill net. Tuticorin Fishing Harbour contributed very meagre. The gill net catch was 126.6 t with a CPUE of 6.5kg/unit in which *Chicoreus ramosus* was dominant with 59% followed by *Turbinella pyrum* (36%), *Lambis lambis* (4%) and from 2019, *B. spirata*

Length and MSD ranges of gastropods landed along Chennai coast

Sl. no	Species	Length (mm) (min-max)	MSD (mm) (min-max)
1	*Babylonia zeylanica*	32.78-67.6	20.45-34.38
2	*Babylonia spirata*	23.38-56.9	14.73-36.74
3	*Tonna dolium*	37.98-87.39	12.32-83.49
4	*Cantharus tranquebaricus*	27.69-63.06	12.65-33.76
5	*Turbinella pyrum*	62.44-95.67	34.7-67.5
6	*Bufonaria rana*	43.89-60.92	25.73-33.87
7	*Bufonaria crumena*	30.93-74.78	24.93-54.04
8	*Nassarius dorsatus*	25.98-31.24	14.5-18.64

1. Month wise gastropod landings in Chennai fisheries harbour
2. The percentage composition of gastropod catches by different gears in Chennai fisheries harbour
3. The percentage composition of *Babylonia* spp. by different gears in Chennai fisheries harbour
4. The percentage composition of gastropod species exploited at Chennai
5. *Turbinella pyrum* collected by skin diving and size graded for marketing
6. Annual Length frequency distribution of *T. pyrum* in gill net (Tuticorin)
7. Annual Length frequency distribution of *T. pyrum* by skin diving (Tuticorin)
8. Annual Length frequency distribution of *C. ramosus* by gill net (Tuticorin)
9. Annual Length frequency distribution of *C. ramosus* by skin diving (Tuticorin)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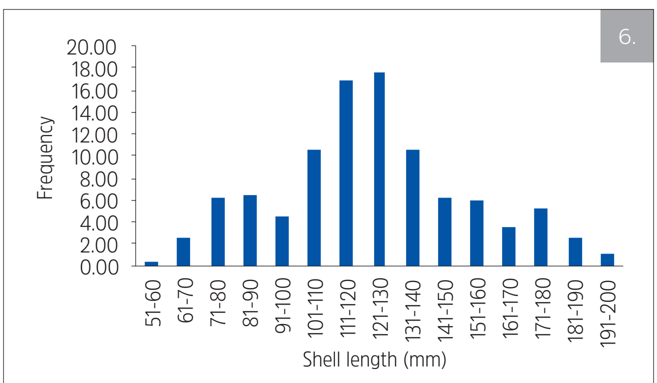

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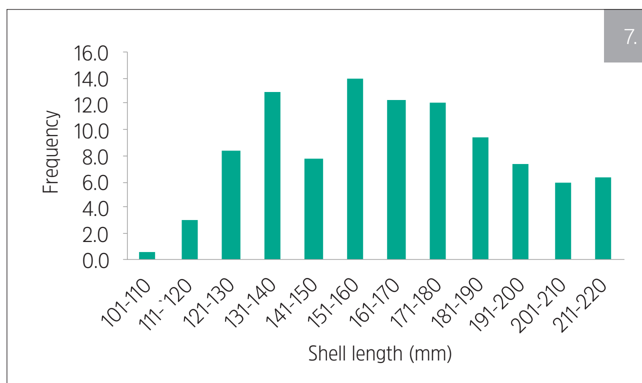

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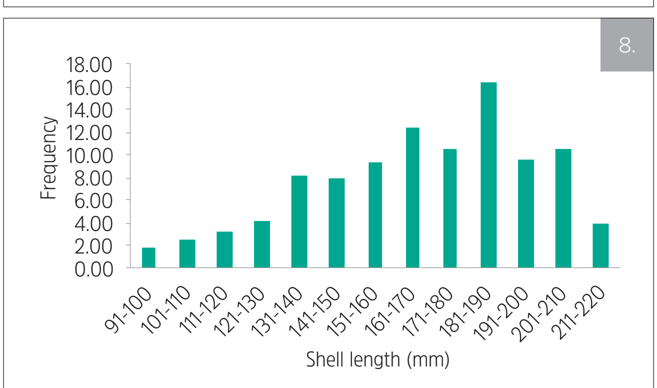

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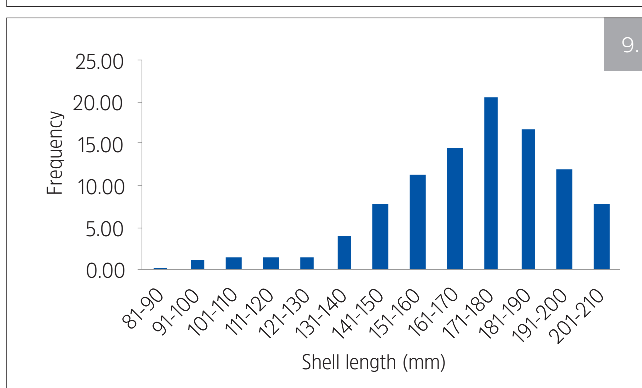

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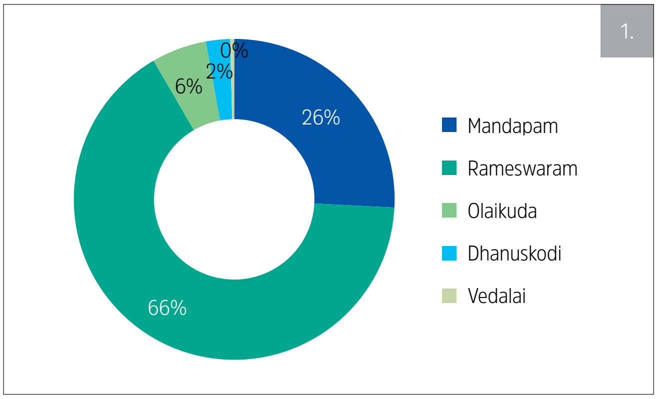
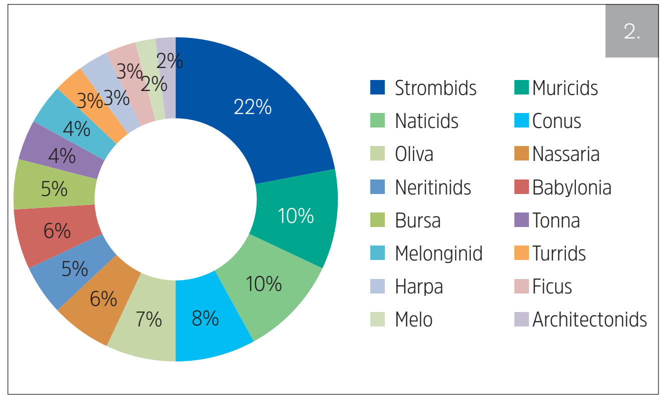




fishery started in this region by gill net. Estimated Skin diving catch was 587.5 t with a CPUE of 8.3kg/person and the contribution was *C. ramosus* (51%); *T. pyrum* (46%) and *Lambis lambis* (3%). The fishery was throughout the year.

Length frequency distribution of major gastropods, *T. pyrum* and *C. ramosus* shows high percentage of large size gastropods were recorded from skin diving.

Population parameters studied for the major species from Tuticorin region; *Turbinella pyrum* and *Chicoreus ramosus* and the exploitation rate of these species was higher than 0.6 which indicates over exploitation

Ramanathapuram

In Ramanathapuram, the total gastropod landing is 1073 tonnes, 92% of the catch is from trawl net and 8% of the catch is from skin diving.

1. Percentage composition of Gastropod landing from Ramanathapuram
2. Group-wise composition of gastropods by trawl net at Ramanathapuram
3. Species composition of gastropods at Kollam

Stock assessment

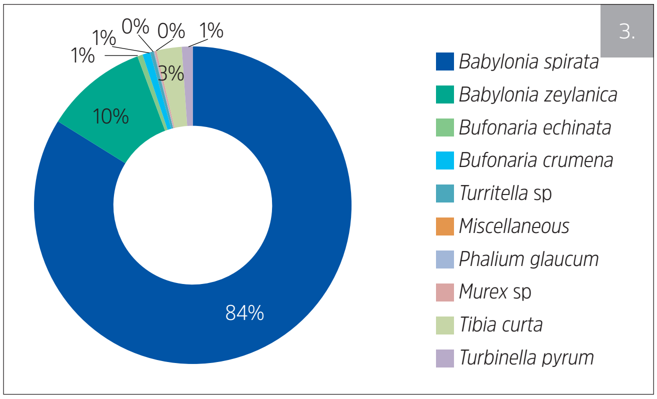
Species	L_∞	K	F	M	Z	E	t_{max}
C. ramosus	257.8 mm	0.42	1.27	0.68	1.95	0.65	7.1

Exploitation of fossilized chank at Kalavasal (Tuticorin)

Centre	Craft	Gear	Catch (t)	CPUE (kg/unit)	CPUE (kg/person)	Fishing season
Kalavasal	Vallam	Skin diving	286	15	2.0	All months

Gastropod landing by Trawlers

Centre	Catch (t)		CPUE (kg/h)	
	2018	2019	2018	2019
Rameswaram	804	706	0.5	1.1
Mandapam	438	278	0.3	0.5



Annual estimation of gastropod landing by diving

Centre	Craft	Catch (t)	CPUE (kg/unit)	CPUE (kg/person)	Species composition (%)			Fishing season
					T. pyrum	*C. ramosus*	*L. lambis*	
Vedalai	Vallam	26	6.3	1.2	54	46	0	Jan, Feb, March, Nov, Dec
Olaikuda	Vallam	52	44	11.1	14	0	86	April-Oct
	Catamaran	9.8	0.7	0.7	35	0	65	April-Oct
Dhanuskodi	Catamaran	4.3	1.6	0.3	100	0	0	Jan, Feb, March, Nov, Dec

Export of gastropod meat

T. pyrum meat consumed by local fishers and its meat wafer has high demand (₹1000/kg). *C. ramosus* meat is exported to Thailand (60 tonnes/year; Local market value: ₹260/kg).

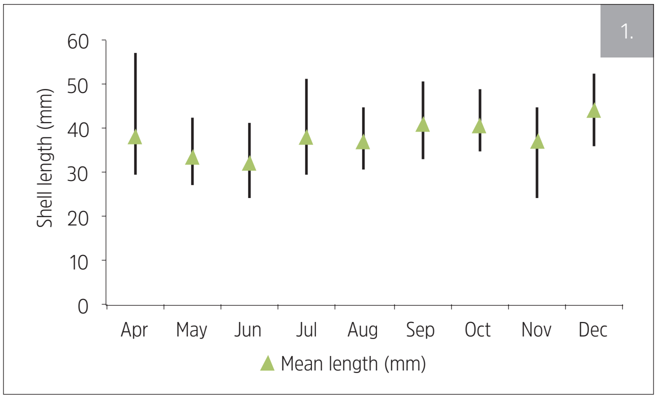
Gastropod opercula trade

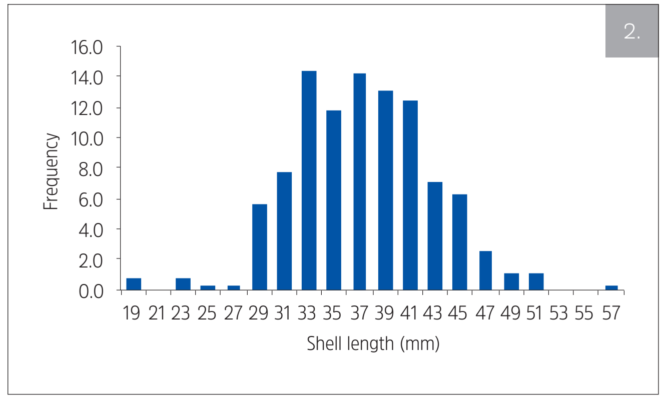
The total estimated gastropod opercula trade consisting of three species ie., *T. pyrum, C. ramosus* and *L. lambis* in 6 landing centres was valued at 271 lakhs during 2019. In the money value, *C. ramosus* contributes 96.5% followed by *T. pyrum* (1.8%) *and L. lambis* (1.6%). *T. pyrum*: ₹2,200/kg; *C. ramosus*: ₹3,700/kg; *L. lambis*: ₹14,000/kg.

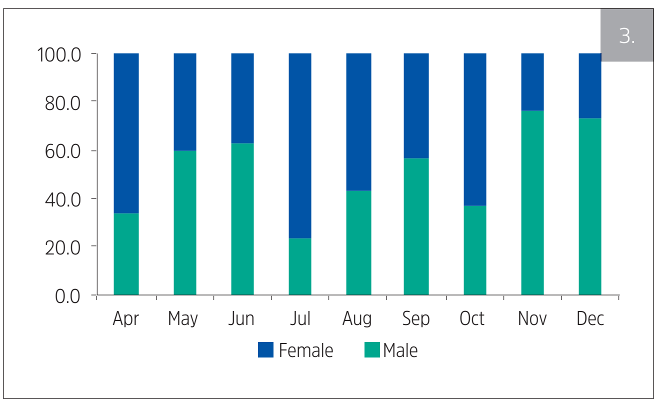
Kerala

The gastropod fisheries were monitored for catch, effort and catch rates at Kollam during 2019. Few years ago in Kollam a large number of species were being exploited and traded and they include *Babylonia, Turbinella, Harpulina, Bufonaria, Rapana, Turritella, Conus, Natica, Tibia, Oliva, Nassarius, Ficus* and *Phallium.* In order to prevent juvenile fishery, in recent years, the strict vigilance from Coastal Police and State Fisheries Department has been carried out at the major landing centres of Kerala including Kollam. Owing to this, trash landings at the landing centres have been reduced because only the trash landings contain the ornamental gastropods which are brought at the landing centres. Gastropods catch was mainly contributed by *Babylonia* species because of its targeted fishery carrying out every year during April – June.

During 2019, the gastropods landing as a by-catch in Kerala coast was 2080 tonnes. Compared to previous year, catch was increased by 35.4%. The entire gastropod catch was contributed by two main gears 92.72% by Single day trawl net (MTN) and 6.9% by Multi-day trawl net (MDTN). .







1. Month wise mean size of *B. spirata* in the fishery–Kollam
2. Annual Length frequency distribution of *B. spirata* in the Fishery (Kollam)
3. Month-wise proportion of sexes of *B. spirata* in the Kollam fishery

Kollam

Babylonia spirata and *B. zeylanica* were the dominant species in the catch forming 99% . *Babylonia* spp. In the bycatch during shrimp trawling throughout the year. However, *Babylonia zeylanica* and *B. spirata* catch were dominant in Kollam landing because the targeted trawling for these whelk was undertaken during April, May and June due to the abundance of resource in these months off Kollam. Whelk trawl net is specially designed notably it has heavy rigging which help this net to plough deep into the sediment and thereby catching these whelk.

Biology

Babylonia spirata length in the fishery ranged from 19.0 mm to 50.5 mm and smallest size appeared in June which might be the spawning season of this species. The largest size was obtained in April. The total weight with shell-on of this species ranged between 3.42 – 28.33 g, and meat weight ranged from 1.85–14.46 g. The population was dominant by females; the sex ratio (Male to Female) was 1:14.

Bufonaria echinata (= Bursa spinosa)

Bursa spinosa length in the fishery ranged from 30.9 mm to 82.5 mm and smallest size appeared in May which might be the spawning season of this species. The largest size obtained in August. The total weight with shell-on of this species ranged between 5.05 – 39.77 g, and meat weight ranged from 1.55 – 15.9 g.

As shell processing is not done in Kerala, large number of ornamental gastropods are transported annually from Kollam to Rameswaram, Tuticorin, Cudallore and Chennai.

Elasmobranchs

Research Projects DEM/ELS/11 & DEM/ELS/SUB/11
FAO-CMFRI Collaborative project on shark & ray non-fin commodities

Landing of juvenile sharks in Mumbai Maharashtra

1

Rays formed 58.4% of the total landed elasmobranchs, sharks, 40.2% and guitarfishes 1.1%. Chimaeras formed 0.3%. Eleven shark genera were dominant in the fishery, forming >98%

1. State-wise contribution (%) to all-India elasmobranch landings in 2019
2. Sector-wise contribution (%) to all-India elasmobranch landings in 2019
3. Composition of elasmobranch landings in 2019

4-6. Composition of sharks, rays and guitarfishes landed in 2019 – major genera

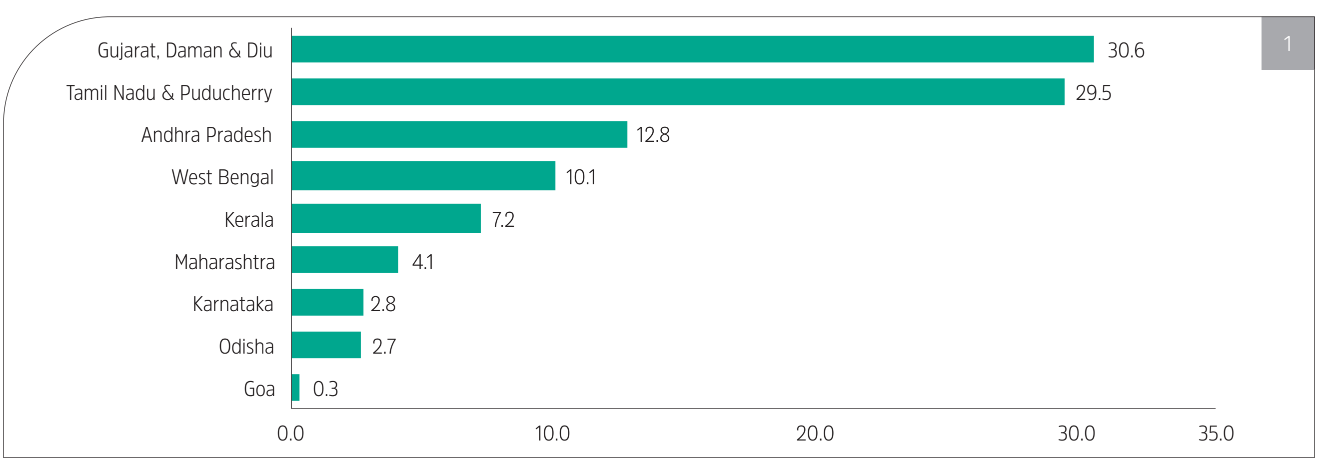
Fishery

Elasmobranch landings in India during 2019 was 43,741 t, increasing by 3.9% from the previous year. The east coast accounted for 55% of the landings and the west coast, 45%. Gujarat & Daman Diu together accounted for 30.6% of the total elasmobranch landings, and Tamil Nadu & Puducherry, 29.5%. The state-wise elasmobranch landings were–Gujarat 12251 t (decline of 0.6% from 2018), Maharashtra 1792 t (decrease of >40%), Karnataka 1215 t (increase of 1.5%), Goa 113 t (>200% increase), Kerala 3143 t (decline of 9.7%), Tamil Nadu 12181 t (decrease by 13%), Andhra Pradesh 5587 t (increase of 170%), Odisha 1163 T (increase of 73%) and West Bengal 4407 t (increase by 13.8%).

The mechanised sector contributed 72.3% of the landings, the motorised sector, 27.2% and the non-motorised sector, 0.5%. Trawl nets contributed to 60.5% of the landings by the mechanised sector, and gill nets, 21.6%. Mechanised operations with combination of trawl net/gillnet and line gear contributed to 11.6% while hook & line operations yielded 1.6%. Gill nets contributed to 83.5% of the landings by the motorized sector while hook & line operations yielded 12.3%. The catch per unit effort in the mechanized sector was 42.5kg for multiday trawl operations, 8.1 kg for single day trawl operations, 73.4 kg for gillnets, 1.6 kg for hook and line operations and 1.1 and 3 kg respectively for trawl net-hook & line and gillnet, hook and line combinations.

Composition of the landings

Rays formed 58.4% of the total landed elasmobranchs, sharks, 40.2% and guitarfishes 1.1%. Chimaeras formed 0.3%. Eleven shark genera were dominant in the fishery, forming >98% of the shark landings in India in 2019. Twelve genera of rays were dominant in the fishery, forming >97% of the ray landings in India in 2019. Four genera of guitarfishes were observed in the guitarfish landings in India in 2019.



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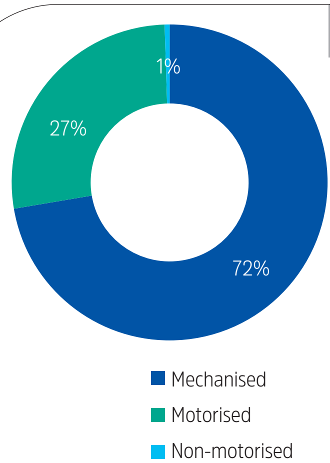

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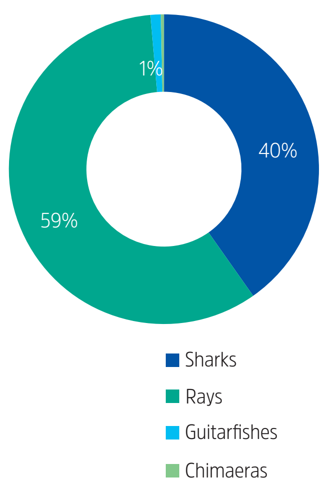

Catch per unit effort (CPUE, kg) of elasmobranchs in mechanized units

	Catch	Units	CPUE (kg)
Gillnet	6839734	93178	73.41
Multiday trawl net	15382838	361962	42.50
Singleday trawl net	3756787	461927	8.13
Hook and line	506039	3833	1.57
Gillnet + Hook and line	1500834	2848	2.98
Multiday trawl + Hook and line	2174538	26038	1.08

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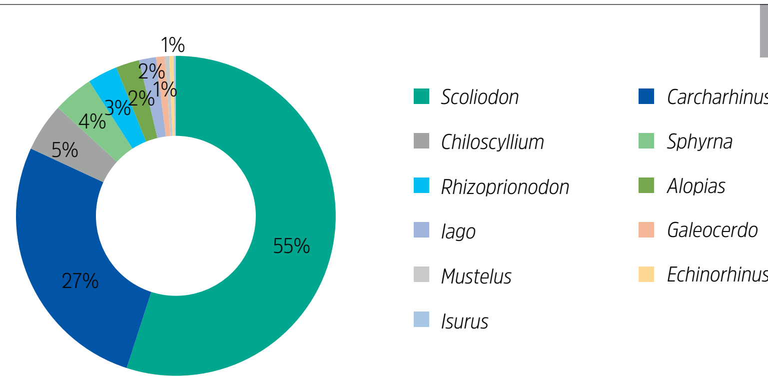

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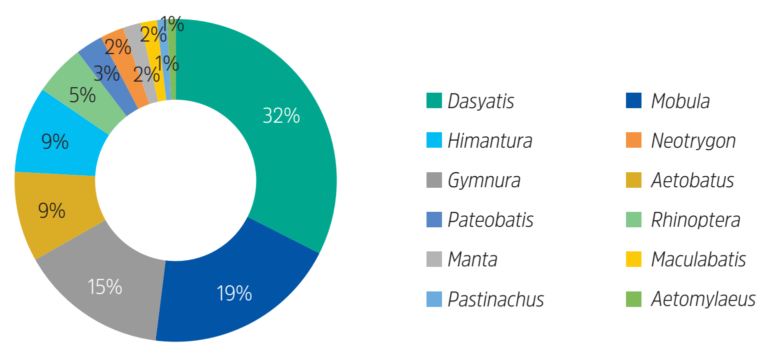

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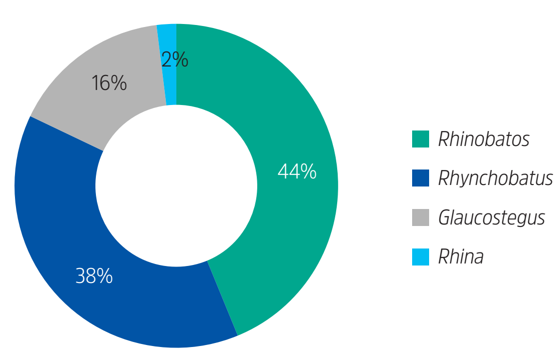


Biology and stock assessment

Biology of most of the species observed in the fishery along the Indian coast was studied. Stock assessment was done for species that were major contributors to the fishery.

Scoliodon laticaudus: The spadenose shark is a major constituent of India's shark fishery and contributed to 55% of the shark landings in 2019. The length range (TL) in the fishery during 2019 was 20-101 cm along the west coast and 25-65 cm along the east coast. Stock assessment studies indicated high exploitation ratios of

1. *Acroteriobatus variegatus* embryos (165-176 mm TL) (Sakthikulangara, Kerala)
2. Sexual hermaphroditism in *Iago cf. omanensis*

0.74 and 0.66 along the northwest and northeast coasts, respectively. The size at first maturity L_{m50} was found to range between 32 cm on the southwest coast to 40 cm on the northwest coast. Reproductive load was found to be higher (0.6) on the northwest coast than on the northeast (0.4) or southwest (0.5) coasts.

Chiloscyllium griseum: Length range of the grey bamboo shark was 53-71 cm TL on the southwest coast, 30-100 cm on the southeast coast and 32-76 cm on the northeast coast. The size at first maturity was estimated to be 45.5 cm. The diet consisted of fishes, octopus, shrimp, squilla and fragments of seaweed and seagrass, while on the northeast coast, these sharks were found to have fed on myctophids, *Coilia,* shrimp and squids.

Neotrygon indica: The Indian Ocean blue-spotted maskray formed a fishery along the east coast. The size range of female *Neotrygon indica* was 15.1-41.9 cm disc width with a mean size of 30.9 cm; while that of males was 10-38 cm with a mean disc width of 28.9 cm. Mature females were seen in all months. Gravid females with late term embryos were seen mainly in October and November. Fed mainly on prawns, squid, *Acetes* spp. and *Stolephorus* spp..

Rhinobatos annandalei: The length range in fishery was 28.5-95.5 cm TL along the northwest coast and 61-90 cm along the southwest coast. The asymptotic length and L_{m50} were estimated as 98 cm and 57.8 cm TL from the northwest coast. Exploitation ratio from this region was 0.54. High incidence of mature and gravid females was observed during November-December along the northwest coast and November-January along the southwest coast.

Rhina ancylostoma: The observed size range in the landings along Kerala coast was 60-210 cm TL (60-70 cm in trawl and 90-210 cm in gillnet and hook & line) . Females were larger and dominated the landings. Diet consisted of juvenile fish, cephalopods and crustaceans (crab, shrimp, squilla).

Rare reports

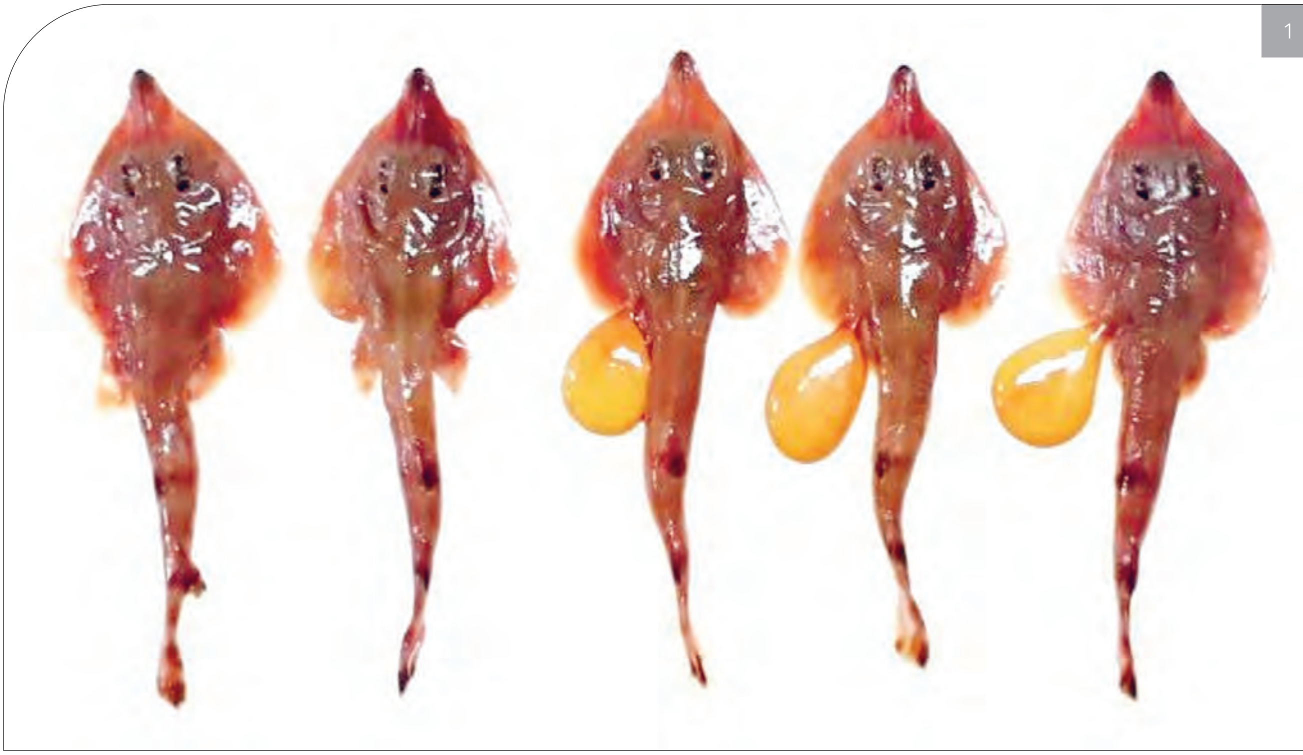
Giant freshwater whipray *Urogymnus polylepis* in West Bengal, India, was captured by trawl nets from waters of the Hooghly River at a depth range of 25-30 m, 50-60 km eastward from Digha (East Midnapur, West Bengal, India).

Landings of juvenile sharks

Juveniles of silky shark *Carcharhinus falciformis* (CITES listed species) and tiger shark *Galeocerdo cuvier* were landed in considerable numbers along the Kerala coast in 2019. About 66% of the annual catch of *C. falciformis* consisted of individuals below the reported size at first maturity. Juveniles of hammer head shark, *Sphyrna lewini* (CITES-listed species), graceful shark *Carcharhinus amblyrhynchoides,* spine tail mobula *Mobula japanica* (CITES-listed species), white-spotted whip ray *Himantura gerardii* and bow-mouth guitarfish *Rhina ancylostoma* were also landed as bycatch by multiday trawl and hook and line fishing along north Kerala coast. High incidence of juvenile sharks was observed immediately after the monsoon trawl ban in Mumbai.

FAO-CMFRI collaborative study on shark & ray non-fin commodities

A collaborative project with Food & Agriculture Organization of the United Nations (FAO), Rome, on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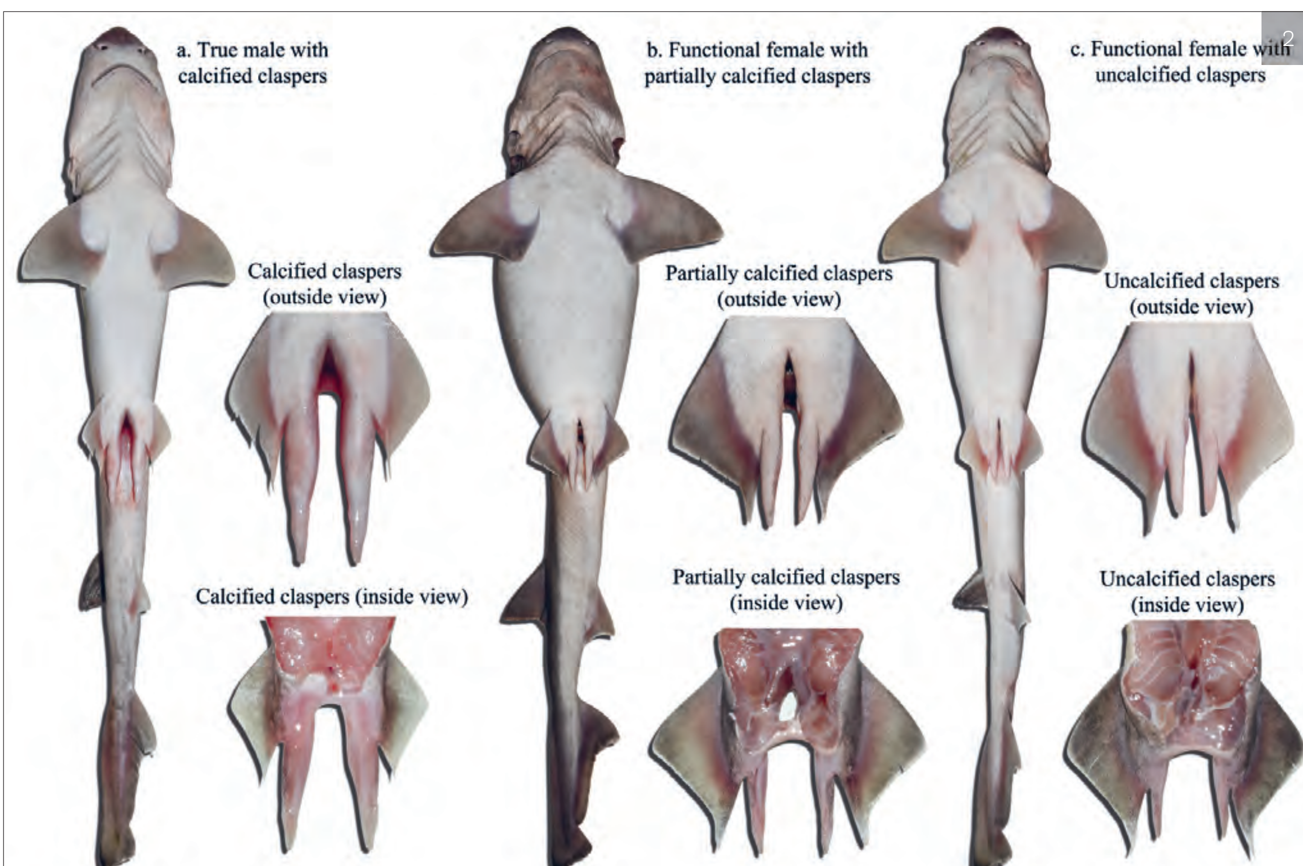
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a. True male with
calcified claspers
Calcified claspers
(outside view)
Calcified claspers (inside view)
b. Functional female with
partially calcified claspers
Partially calcified claspers
(outside view)
Partially calcified claspers
(inside view)
c. Functional female with
uncalcified claspers
Uncalcified claspers
(outside view)
Uncalcified claspers
(inside view)

Shark & Ray Non-Fin Commodities was initiated in May 2019. The project, which is part of FAO's global project, is aimed at mapping the value chain of elasmobranch non-fin commodities to help in promoting sustainable exploitation, utilisation and management of these important resources. The outcome of the project will be a country-level reporting to gain an understanding of the scale, value and importance of non-fin commodities of sharks and rays in India. Questionnaire-based surveys of fishers, aggregators and traders were conducted across 34 landing centres in mainland India.

FAO-CMFRI Global Expert Meeting

A Global Expert Meeting on shark trade and data collection, jointly organized by Food and Agriculture Organization of the United Nations (FAO, Rome) and ICAR-CMFRI, was hosted at CMFRI, Kochi from 24 to 27 July 2019. It was attended by representatives from FAO (Rome, Italy) and experts from UK, UAE, Australia, Mexico, Argentina, Indonesia, Malaysia, Sri Lanka, Nigeria, Somalia, Myanmar and Namibia. Dr Kim Friedman, Senior Fishery Resources Officer of FAO led the discussions which focused on developing a solid frame work that will be used to publish well-informed guidelines, that all countries could use to improve data collection and mapping of value chains to promote sustainable fishing and trade of this vulnerable marine resource group.

Status of protected elasmobranchs

Surveys were conducted to understand the status of elasmobranchs protected under the Indian Wildlife (Protection) Act, 1972. Awareness workshops for stakeholders were conducted at all centres in conjunction with stakeholder meetings on fishery and trade. Awareness pamphlets "Save our Sharks" in local languages were distributed at all stakeholder meetings.

1-3. FAO CMFRI Global Expert Meeting

4-6. Accidental catches of protected species during 2019

Accidental catch of whale shark *Rhincodon typus* was reported from different parts of the country, with some possible cases of poaching. The sawfish, *Pristis pristis* was accidentally caught in Tamil Nadu, Andhra Pradesh and West Bengal. The porcupine ray, *Urogymnus asperrimus* was reported in bycatch of fishing operations in Karnataka, Kerala and Tamil Nadu.

- *Pristis pristis* (Chemmencherry, TamilNadu, August 2019)
- *Urogymnus asperrimus* (Pamban, Tamil Nadu, December 2019)
- *Rhincodon typus* (Karnataka)

Enquiries made at Dummulapeta in Andhra Pradesh showed that fishermen no longer landed whale shark in that landing centre. In earlier years, this used to be the major landing centre for the protected whale sharks. This change in fishermen's attitude indicated towards improved awareness and effective enforcement of laws in the area. Several reports of the successful live release of whale sharks have been reported from Gujarat, Kerala, Tamil Nadu, Andhra Pradesh and Odisha, which too indicate the change that can be brought about through awareness campaigns.


1.


2.


3.


4.

1&2 Distribution of posters and pamphlets to stakeholders at Mumbai, Maharashtra and Pamban, Tamil Nadu

3&4 Awareness programme on 'Conservation of Protected Elasmobranchs' organized at Ponnani Fishing Harbour, Malappuram District, Kerala different centres

Awareness workshops and stakeholder meetings

Thirteen awareness workshops and stakeholder meetings were organized in all the states through the respective centres of CMFRI. The participants included officials from the State Fisheries Departments, Coastal/ Marine Police, Forest Departments, Coast Guard, Navy, WCCB, Veterinary Department and NGOs. Discussions were focused on identification of protected and CITES listed species, status of elasmobranch fisheries and trade in India and need for shark conservation and management in the region. Posters and awareness pamphlets in local languages were distributed to all the participants at the meetings and also at different landing centres on 30 August 2019, which is the International Whale Shark Day.

Non-detriment Findings on silky and thresher sharks

Non-Detriment Findings documents have been published for the silky shark, *Carcharhinus falciformis* and the thresher sharks, *Alopias* sp. for the Indian Ocean, valid for the period 2019-2022. Both NDFs are "positive with conditions" to enable non-fin commodity trade to continue in the concerned species while improvements are made to existing fisheries and trade management and monitoring frameworks. The NDFs will be re-evaluated after 3 years, to gauge progress against the recommendations made and updated with newly acquired data, before agreeing to new NDFs for ensuing years.

Stakeholder's Consultations

CMFRI organised stakeholder meetings and awareness programmes at its headquarters and different regional and research centres during 2019

Kochi

The stakeholder consultation meeting and awareness campaign was organised at Cochin Fisheries Harbour on 28th September 2019. The meeting was attended by more than 60 stakeholders including the scientists and technical staff of CMFRI, Gillnet and hooks and line operators, buying agents, elasmobranch wholesalers and retail traders, officials from Wildlife Crime Control Bureau, Fisheries Department, Kerala and Wildlife Trust of India. The status of elasmobranch fishery, trade, utilisation and conservation in India was presented by CMFRI, which was followed by intensive deliberations on shark trade and conservation along the Indian coast. The official from WCCB sensitised the fishermen and traders on the importance of conservation of sharks and the penalties imposed for fishing the protected species. The fishermen/trader representatives raised their concern on some of the policies such as the blanket ban on shark fin trade which impart huge loss to the fishermen community as well as to the economy and extended their willingness to share relevant information from their side and offered wholehearted support to the efforts made by CMFRI for bringing out management plans for the sustainable management of elasmobranch resources along the coast of India.

Calicut

Stakeholders' meet on trade of sharks and rays were conducted at the Central Market, Calicut on 24th September 2019. Along with the fishermen and allied workers, the representatives of Kerala State Fish Traders Association were also present in the meeting. The importance of elasmobranchs, the status of protected species were presented to the participants. Discussions mainly focussed on issues faced by the shark fishermen and the need for more awareness on identification of protected species by the fishermen to release them back to the sea. Another Stakeholders' Workshop was organised on 30th November 2019 under the KSBB sponsored project on Valuation of marine and coastal ecosystem and the major issues discussed were conservation of mangrove ecosystem, Combating plastic pollution in the Community Reserve, loss of biodiversity through anthropogenic activities such as felling of mangrove trees, reclamation of wetlands for construction of houses and aquaculture ponds etc

Mangalore

Stakeholders' Meet was conducted on shark trade and conservation at Coastal police premises on 20th September 2019. The importance of elasmobranchs, gears used for harvesting elasmobranch resources, commercially important elasmobranch species, and identification of protected elasmobranch species, laws and regulations for their conservation, future research needs for conservation of elasmobranchs were presented to the participants. The fishermen and allied workers expressed their interest to have more awareness on the proper identification of protected species along the coast of India.

1. Stakeholder meeting held at Central Market, Calicut
2. Stakeholder meeting at Worli village, Mumbai
3. Stakeholder meeting at Mangalore

1.

Mumbai

Awareness meet on threatened and protected marine fauna was conducted at Worli, village, Mumbai on 20 September 2019. Nearly 60 fishers attended the programme. The issues and conservation needs were presented to the participants by CMFRI officials. The key issues that came up for elaborate discussion in the meeting was on the increasing concern on the incidental landings of protected marine fauna and the procedures followed while such species are landed along the state. The fishermen also appreciated the efforts taken by CMFRI to create awareness and help the fishermen to identify the important protected species of elasmobranchs of the country.

Chennai

Stakeholder's meeting on "Fishery and Trade of Sharks & Rays" was convened at Madras Research Centre of CMFRI on 25 September 2019. Awareness generation on ETP species, regulations on fishery and trade of different species and creation of information sharing platforms to enable better monitoring of these resources were the objectives of the meeting. Stakeholders interacted with the scientists at length on issues in the fishery and trade of elasmobranchs in India. The major concerns discussed were the need for consultation of CMFRI by Govt. on making decisions on regulations on fishery and trade of elasmobranchs, need for creating more awareness on protected species with identification keys and photographs, sharing relevant information from the side of officials and fishermen, revision of blanket ban of shark fin trade of punishment by government in the event of incidental landings of protected species etc.

Visakhapatnam

Pre-survey awareness meet at the centre on "Shark and Ray Non-Fin Commodities" under the FAO funded Shark and Ray Non Fin Commodities project on 30th September 2019 at Vizag. to discuss the issues pertaining to the need for avoiding the harvest of protected species along the coast. Programme, including presentation and quiz competition were held for increasing awareness regarding conservation status of elasmobranchs.

1. Stakeholder at the meeting held at Chennai
2. A fisherman sharing his thoughts during the stakeholder meeting held at Visakhapatnam
3. Stakeholder speaks at the meeting at Puri

Puri

A "Pre-survey Awareness Workshop" was held on 30th September 2019 at Fisher's Community Hall, near Pentakota landing centre, Puri. More than 60 participants including fishers, traders, auctioneers, social workers, and scientists and other staff members of Puri field centre of CMFRI attended the meeting. An awareness programme was held on "Conservation of Elasmobranchs" on 20th December 2019 at Chandrabhaga, Puri in collaboration with the District Forest Office, Puri during the awareness programme on olive ridley turtle protection. More than 200 participants including fishers, District Forest Officer, Puri and Forest range Officers, Marine Police, Assistant Fisheries Officer and other officials attended the programme.

1. Stakeholder interaction in the meeting at Digha

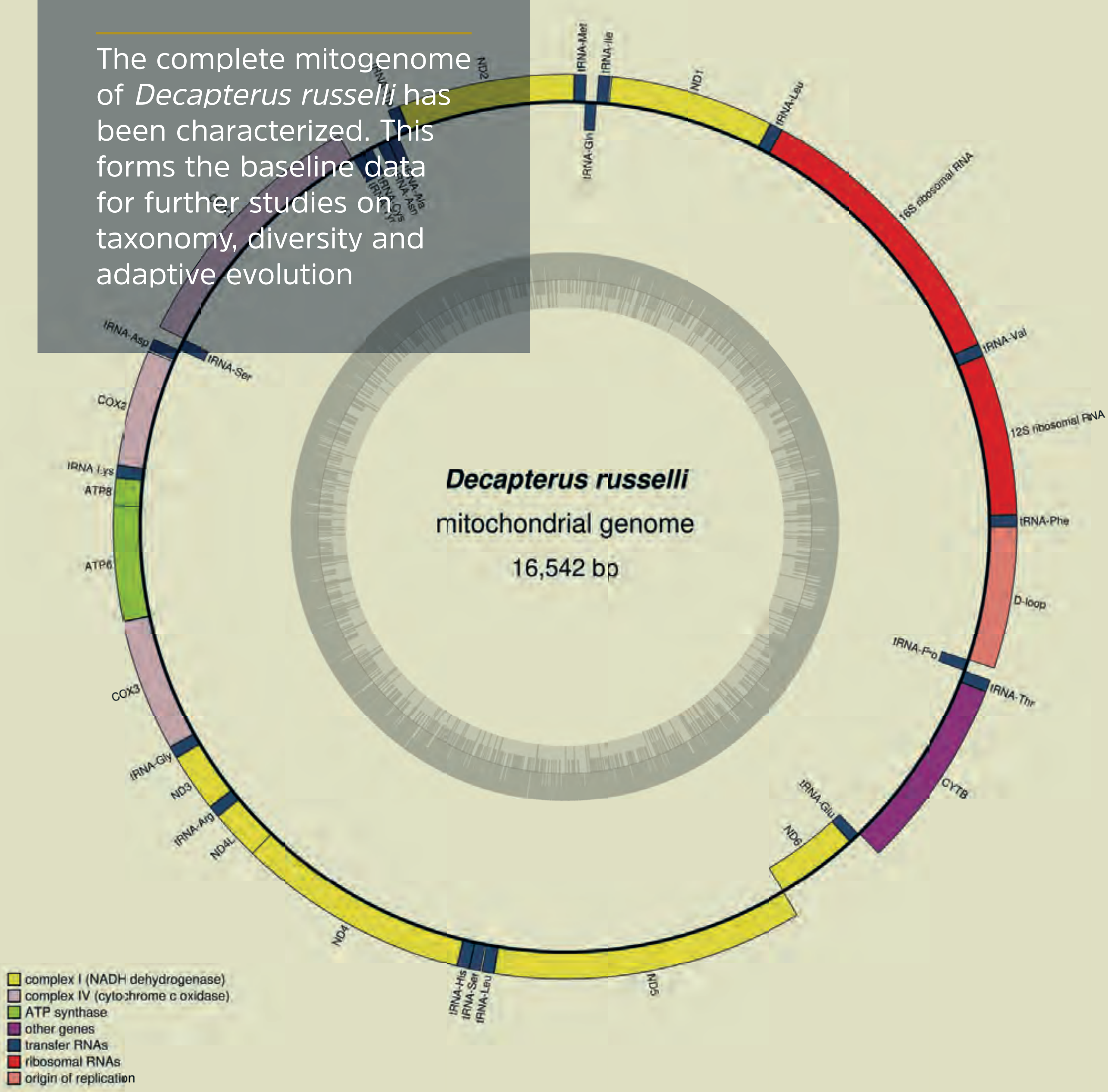
Digha

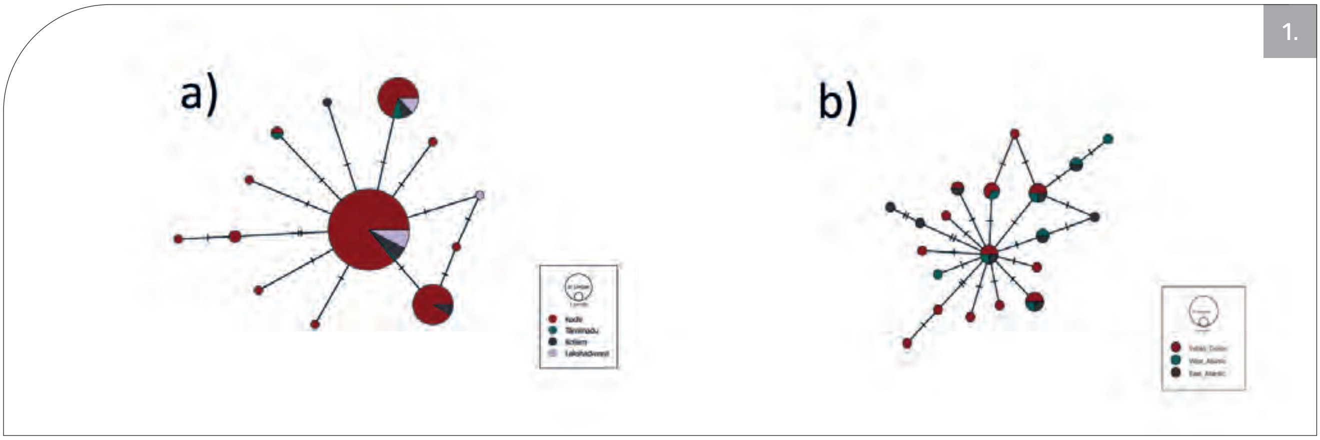
An awareness workshop on "Protected elasmobranch resources of India and legislations' was organised on 24th September, 2019 at Digha Mohana landing centre in West Bengal. The major discussions were on fishing of elasmobranchs by foreign vessels, need for new government regulations to curtail the fishing of pregnant and juvenile sharks, and formation of a committee for conservation of sharks. They also demanded state fisheries department to provide compensation to fishermen for breaking the net and releasing the protected species. Another awareness workshop on "Trade of shark and shark non-fin commodities' was organized on 28th September, 2019 at Soula fish landing centre in West Bengal.

Genetics and genomics

Mitogenome of the Indian scad, *Decapterus russelli*

The complete mitogenome of *Decapterus russelli* has been characterized. This forms the baseline data for further studies on taxonomy, diversity and adaptive evolution





1.

Characterization of the complete mitogenome of the Indian scad, *Decapterus russelli*

The complete mitogenome of the Indian scad, *Decapterus russelli* has been characterized. The circular mitochondrial DNA molecule is 16542 base pair (bp) in length which included a standard set of 13 protein coding genes, 22 transfer RNA genes (tRNA) genes, 2 ribosomal RNA genes (12S rRNA and 16S rRNA), and non coding region.

Genetic stock structure investigations on oceanic white tip shark, *Carcharhinus longimanus*

Genetic population structure of Oceanic white tip shark has been characterized using mitochondrial control region markers. Significant genetic differentiation was not detected along Indian coast indicating the migratory capabilities of oceanic white tip sharks within Indian coast. Global comparisons indicated significant structuring between individuals of Indian and West Atlantic coasts indicating the presence of oceanographic barriers preventing the migration of oceanic white tip sharks.

Phylogenetic investigations on Indian Ocean squid, *Uroteuthis duvauceli* indicated the presence of cryptic diversity as 3 different clades were detected along the Indian coast. Samples from the west coast of India (Veraval, Mumbai, Mangalore and Kochi) clustered separately from those of the east coast of India (Chennai, Vizag Puri and Digha). Within the east coast, samples from Chennai were genetically diverged (forming a subclade) as compared to samples from Vizag, Puri and Digha.

Adaptive evolutionary patterns of Indian oil sardine in the Indian ocean region

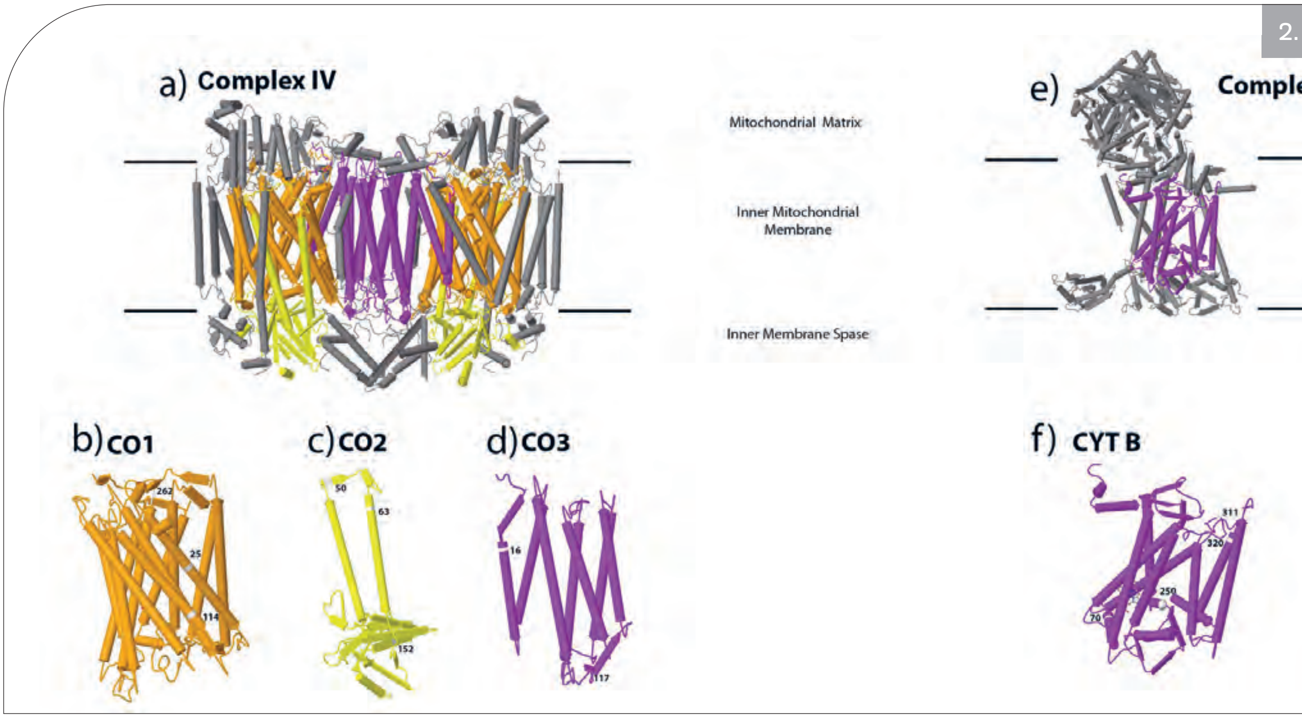
The adaptation and selection patterns in mitochondrial genome of Indian oil sardine were studied and correlated with habitat characteristics. Selective constraints were prevalent more among individuals from South Eastern Arabian Sea (SEAS) followed by the Northern Arabian Sea (NAS) and rare in Bay of Bengal (BoB) populations. Fishes belonging to SEAS exhibited accelerated substitution rate mainly due to the selective pressures to survive in a highly variable oceanic environment characterized by seasonal hypoxia, variable SST and food availability.

Transcriptomic investigations in *Paphia malabarica*

Transcriptomic investigations in *P. malabarica* provided insights regarding upregulated and downregulated genes in individuals collected from Ashtamudi and Dharmadam estuaries providing clues regarding the influence of environment on expression of genes.

Cryptic speciation in the mud spiny lobster, *Panulirus polyphagus*

Two cryptic subspecies have been documented in the mud spiny lobster, *Panulirus polyphagus* using whole mitogenome and partial mitochondrial DNA analysis (COI and control region). The genetic divergence between the two sub-species was 7.5%. The 'subspecies A' dominated in the Bay of Bengal (East coast collection sites-



1. Haplotype network diagram constructed using control region sequences of C. longimanus

2. Positively selected sites in Cytochrome *C Oxidase* (Complex IV) and Cytochrome bc 1 (Complex III) of *S. longiceps*. Grey structures represent nuclear-encoded subunits. a) OXPHOS Complex IV (Homodimer) with mitochondrial-encoded subunits represented in different colors: CO1 in orange, CO2 in yellow, CO3 in magenta. e) OXPHOS Complex III with mitochondrial-encoded subunit represented in magenta color. Individual core subunits b) CO1, c) CO2, d) CO3 and f) CYT B with amino acid site number at positively selected sites.

Digha, Chennai) while 'subspecies B' dominated in the Arabian Sea (Veraval, Mumbai). The two were observed to coexist at Rameswaram with more number of subspecies A. The divergence at species level may be due to adaptive genetic differentiation.

Phylogeographic evidence of stock structure in *Scomberomorus guttatus*

Phylogeographic evidence of stock structure has been recorded in *Scomberomorus guttatus*. 30 samples each were collected from the west (Veraval, Mumbai, Mangalore) and east coasts (Puri, Vizag) of India. Phylogeographic analysis was carried out using COI sequences from the present study and compared with sequence datasets available in NCBI GenBank. ML analysis revealed two robustly supported clades with a significant genetic divergence of 2.42%, signalling a strong genetic population division.

Transcriptome profiling of green mussel, *Perna viridis*

The transcriptome profiling and *de novo* assembly of transcripts of healthy adductor muscle and mantle tissue of the green mussel *Perna viridis* collected from Pulicat lake is being carried out to unravel the expression of genes involved in major biochemical pathways. The sequence library preparation of 25 million reads, each around 150 bp paired end sequences is being carried out by Illumina sequencing. The *de novo* assembly of transcriptome of adductor muscle and mantle tissue could be used as biomarkers for ecotoxicological studies and biomonitoring.

Gene expression investigations on orange spotted grouper, *Epinephelus coioides*

Effect of different stocking density, feeding frequency and growth hormone and insulin-like growth factor gene expression were correlated with growth performance of orange spotted grouper. Fishes were stocked at three different stocking densities and fed at different feeding frequencies. The expression of growth hormone and insulin-like growth factor were studied. Gene expression correlated well with the growth of fingerlings.

Genetic investigations on Cobia brood stock

Genetic divergence of broodstock of Cobia, *Rachycentron canadum* reared at Mandapam Regional centre of CMFRI is being investigated using microsatellite markers.

Genetic investigations on green tiger shrimp, *Penaeus semisulcatus*

The Genetic stock Identification (GSI) of green tiger shrimp, *Penaeus semisulcatus* is being carried out to evaluate the impact of sea ranching on shrimp landings using polymorphic microsatellite molecular markers

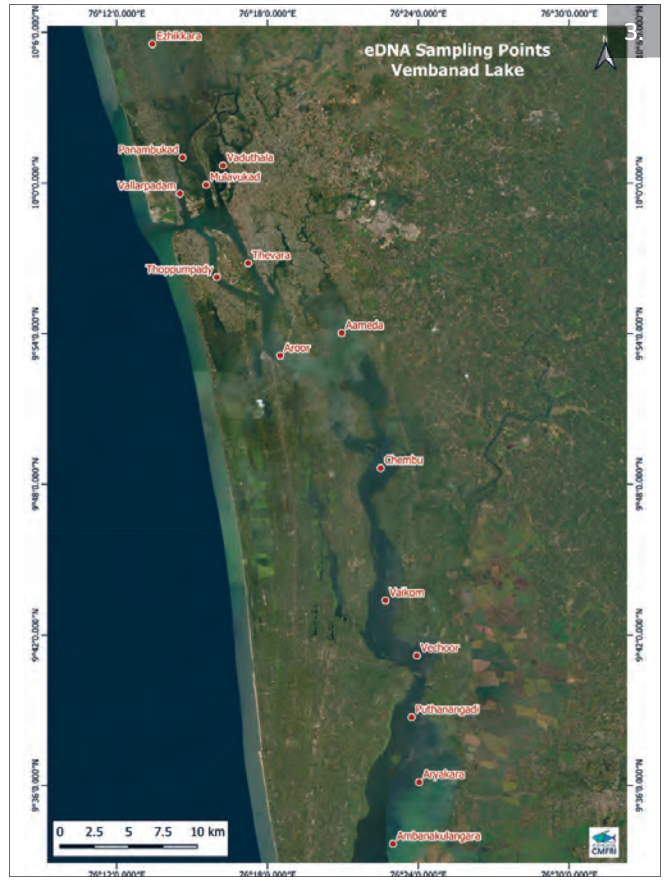
Environmental DNA (eDNA) metabarcoding based estimation of marine stocks (MBT/DNA/37)

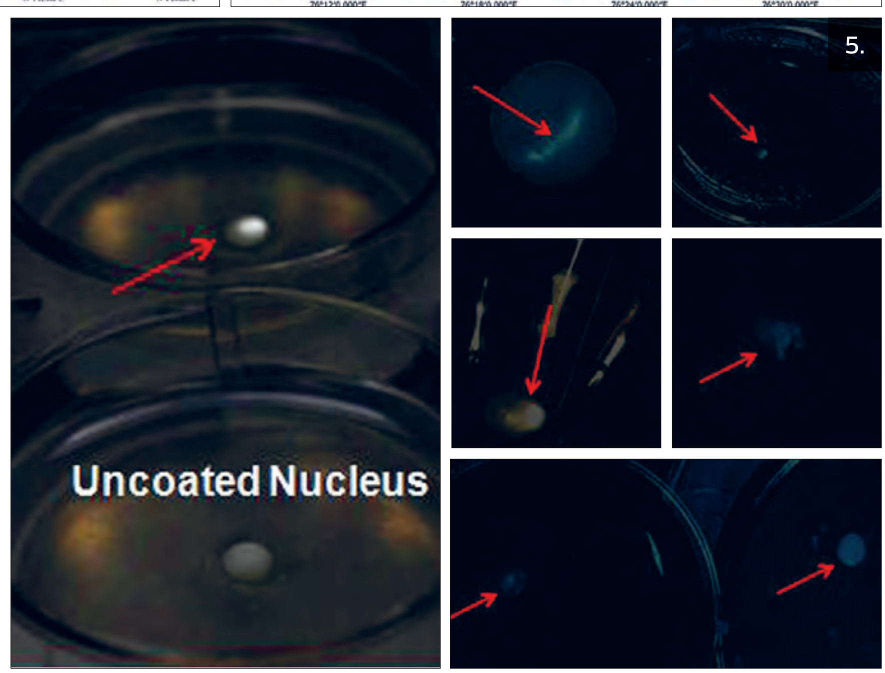
The fish population diversity of Kumarakom backwaters was studied using eDNA based approach. Water samples were collected from 3 different locations in Kumarakom backwaters; eDNA was purified and PCR-amplified using MiFish primers. The amplicons were NGS-sequenced and analysed. Around 200 unique contigs were obtained of which 53 contigs were of fish species previously reported from Vembanad Lake. The novel contigs and their corresponding species need to be identified by traditional taxonomy. Further, there is a need to generate DNA barcodes for those species which do not have corresponding matches in the database.

Sampling locations from Kochi [Vembanad Lake], Mandapam, Vizhinjam and Kavaratti were identified and tagged based on interactive GIS. Sampling locations were identified with the help of imageries based on bathymetric, local geological and geographical considerations. The sampling points were converted to live maps for making the field survey and locating the sampling ports easy, so that it could be overlaid onto Google earth and made available on smartphone.

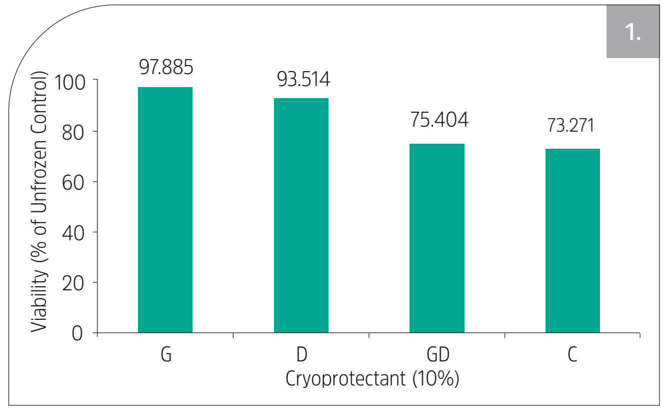
Biomineralization of mantle tissue from pearl producing molluscs (MBT/TSU/26)

An intense, thick, lustrous hue covering larger surface area and formation of pearly nacreous material was noticed on several bead surface under *in-vitro* conditions using cultured mantle epithelial cells from *P. margaritifera.*





1. GIS-based mapping of sampling location Kavaratti.
2. GIS-based mapping of sampling locations at Mandapam.
3. GIS-based mapping of sampling locations at Kochi.
4. GIS-based mapping of sampling locations at Vizhinjam.
5. Lustre formation on *in-vitro* nacre coated beads incubated in semi-solid substrate with cultured mantle epithelial cells of *P. margaritifera*



The trails on nuclear beads for lustrous nacre coating indicate the ability of *in-vitro* cultured mantle epithelial cells to retain its functional potential and higher repeatability cum reproducibility of *in-vitro* nacre coating trials. This is the first time that formation of a pearly nacreous material on several bead surfaces was achieved under *in vitro* conditions. A protocol was established to cryopreserve the *in vitro* cultured mantle epithelial cells of *P. margaritifera* in viable condition for longer duration (60 days). Ten percent concentrations of both glycerol and DMSO provided optimum cryoprotection, with 94-98% post thaw viability.

Trials using cryopreserved cells to induce nacre deposition on nuclear beads in a semi-solid substrate revealed a good, brick and mortar, pattern after 60 days of incubation (as revealed by SEM and EDAX), characteristic of nacreous layer formation, comprising of aragonite platelets and matrix proteins with an increased concentration of calcium. Analysis of a cross section of the nacreous portion of the bead nucleus also confirmed nacre formation and increased calcium concentration.

Rhombohedral calcium carbonate crystals, involved in nacre biomineralization, secreted by cryopreserved, *in-vitro* cultured mantle epithelial cells was noticed for the first time.

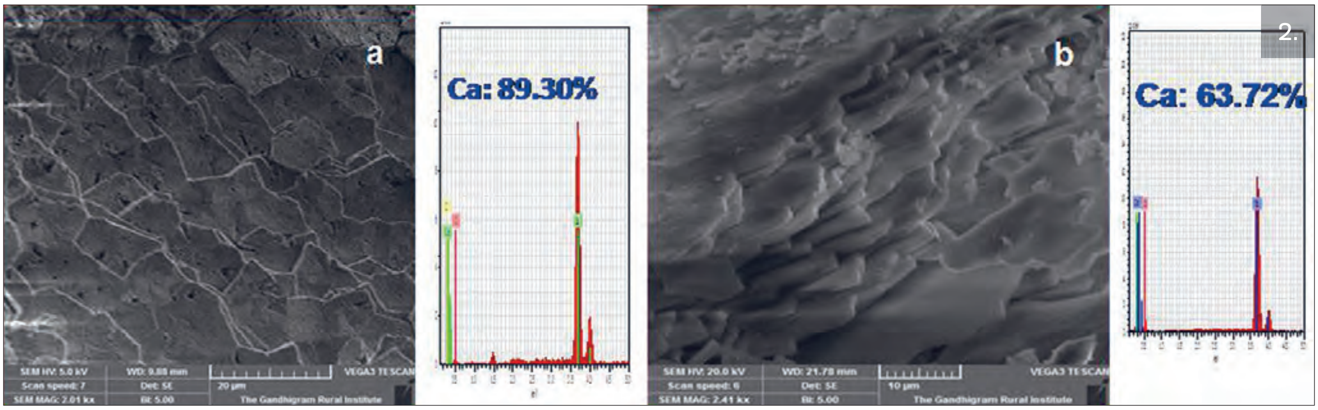
The functional analysis of *in-vitro* cultured mantle epithelial cells in nacre biomineralization was studied by analyzing the expression of genes namely Lustrin (LST), Amorphous Calcium Carbonate Binding Protein (ACCBP), Carbonic Anhydrase 1 (CA1) and Mollusc shell framework protein (MSF). The partial cDNA sequences have been amplified and amplicons sent for sequencing.

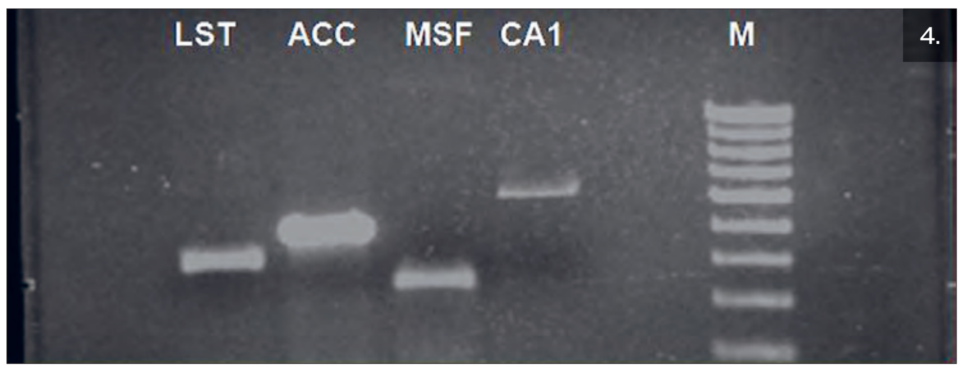
Experimental trials were conducted using Flow Cytometry to analyze the nuclear DNA content of epithelial cells from fresh mantle tissue and *in-vitro* cultured cells.

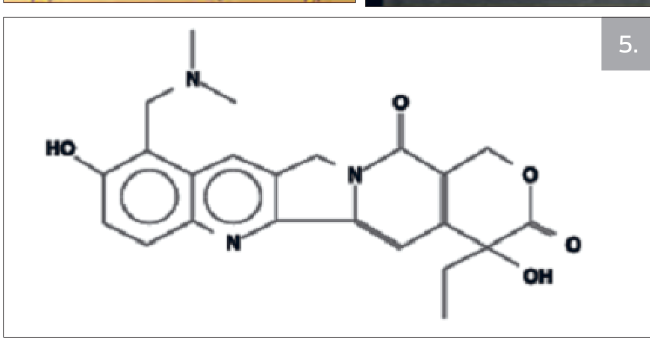
The major bioactive compounds from the extract of mantle tissue of *P. fucata* were identified by GC-MS analysis as Topotecan, an anti-cancerous agent and 4-Fluorohistamine, a powerful stimulant of gastric secretion as well as a centrally acting neurotransmitter.

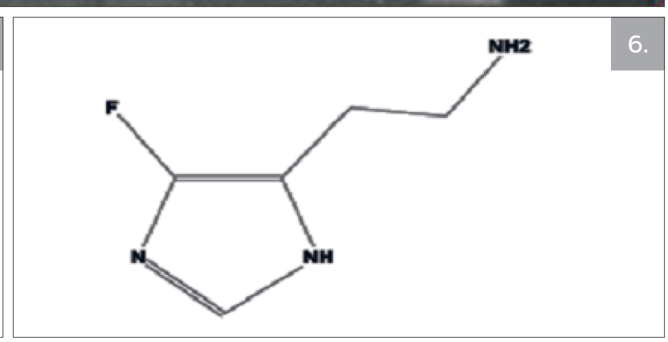
Biopolymer coated beads were produced with coating of carrageenan, collagen & chitosan extracted from seaweeds, fish skin and shrimp shell, respectively to understand the level of

1. Cryoprotective effects of 10% glycerol (G), dimethyl sulfoxide (D) and a mixture of the two cryoprotectants (GD) on post thaw viability of *in-vitro* cultured mantle epithelial cells of *P. margaritifera* after storage at low temperature for 60 days; C–Frozen control
2. Nacre deposition on nuclear beads using cryopreserved *in-vitro* cultured mantle epithelial cells of *P. margaritifera*; a: Full bead; b: Cross section
3. Rhombohedral calcium carbonate crystals involved in nacre biomineralization using cryopreserved *in-vitro* cultured mantle epithelial cells of *Pinctada margaritifera*
4. Matrix proteins gene expression; Lustrin (LST, 362 bp); Amorphous Calcium Carbonate Binding Protein (ACCBP, 500 bp); Molluscan Shell Framework protein (MSF, 350 bp) ; Carbonic Anhydrase 1 (CA1, 650 bp); M – 100bp DNA Ladder
5. Structural formula of Topotecan
6. Structural formula of 4-Fluorohistamine
7. Scanning electron microscopic view of collagen-chitosan coated bead



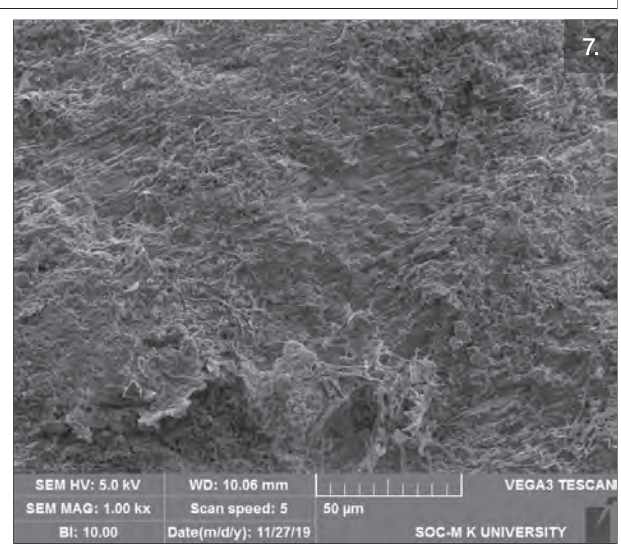


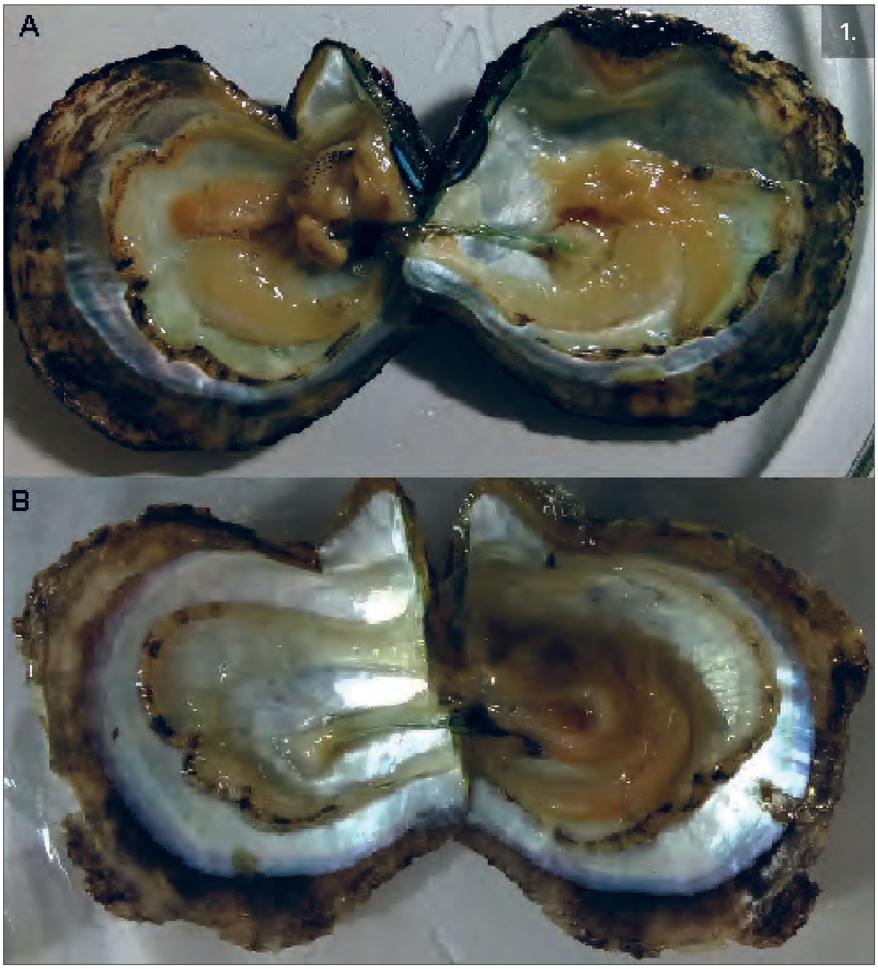


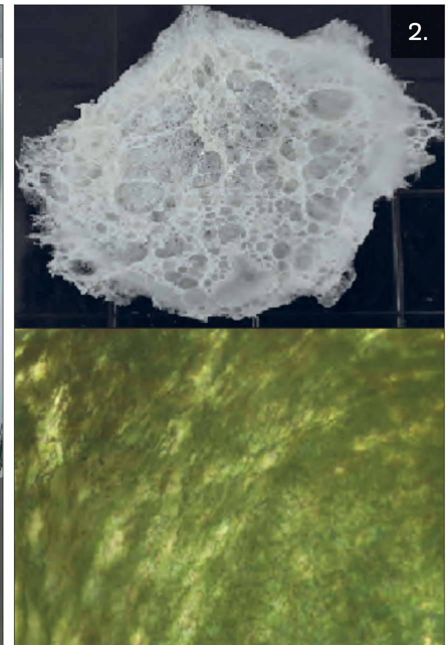


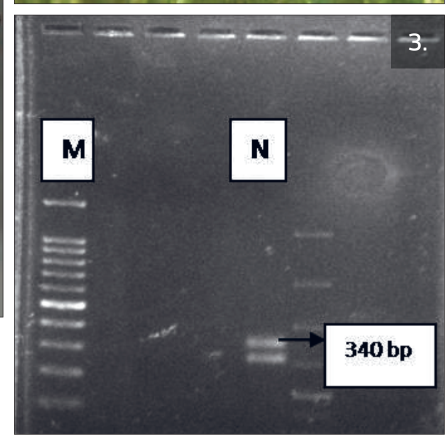
nacre deposition and subjected to SEM analysis. Trials were initiated with mantle cells of *P. fucata* over the better coated beads of the collagen-chitosan.

Scaffolds were developed with the combination of collagen-chitin, collagen-carrageenan and collagen-chitin-carrageenan complex to test the affinity of mantle cells over them. Among them, scaffolds of collagen-chitin-carrageenan complex showed better affinity to mantle cells. An experiment was conducted to study the effect of









minerals, ammonium molybdate (7, 3.5 ppm) and manganese sulphate (26, 13 ppm) on nacre colour of the pearl oyster, *P. fucata.*

The oysters treated with ammonium molybdate showed slight pinkish colour and manganese sulphate treated oysters showed black colour tinge over the nacreous layer.

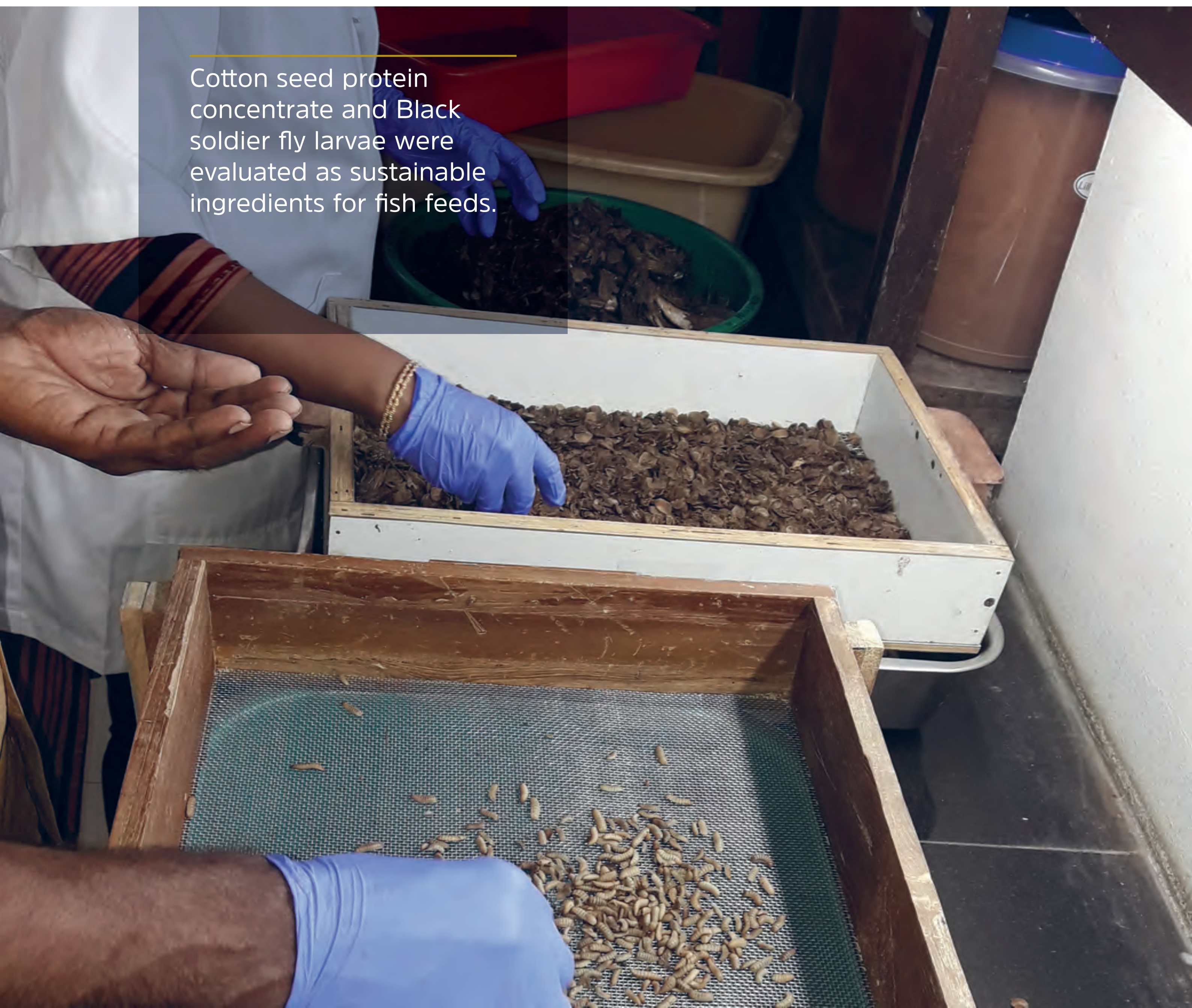
RNA isolation was carried out from the mantle tissue samples of *P. fucata* and cDNA synthesis was done. The sequence of biomineralization related mantle-tissue gene nacrein was carried out, annotated and submitted to NCBI.

1. Inner nacreous layer of ammonium molybdate and manganese sulphate treated *P. fucata*
2. Collagen-chitosan-carrageenan scaffold B. Microscopic view of the scaffold 10X
3. Nacrein gene from mantle tissues of *P. fucata*. M, Marker 100 bp; N, Nacrein gene 340 bp

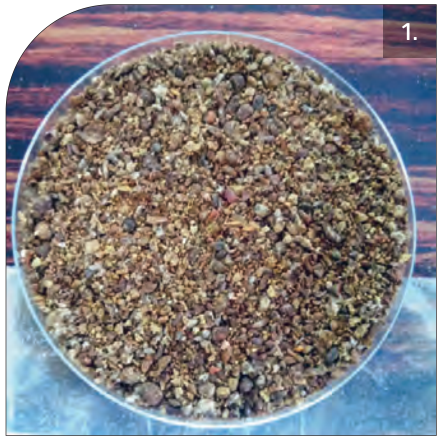
Fish Nutrition

Research project: MBT/NTM/24

Black soldier fly larvae harvesting



Cotton seed protein concentrate and Black soldier fly larvae were evaluated as sustainable ingredients for fish feeds.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Marine food fish, ornamental fish and lobster nutrition research for mariculture

Research project: (MBT/NTM/24)

Cottonseed protein concentrate preparation protocol and mass production

The protein concentrate preparation protocol from cottonseed meal was standardized and the protocol witnessed the yield of 24-31% of cottonseed protein concentrate. The protein content of protein concentrate was 69-71% which increased from 42% in the cotton seed meal. The protein content of spent material was in the range of 22-26%.

Growth and haemato-immunological responses of snubnose pompano fed with the diet substitute with varying levels of cottonseed protein concentrate in place of fishmeal

An experiment was conducted to evaluate the effect of fishmeal replacement with cottonseed protein concentrate (CSP) on growth and haemato-immunological responses of snubnose pompano, *Trachinotus blochii*. The fishes with the average weight of 4.05 ±0.3 g were stocked in five different treatments (0CSP, 25CSP, 50CSP, 75CSP and 100CSP) each in triplicates. The percent ingredient composition is shown in the Table. Four iso-nitrogenous (40% CP) and iso-caloric (6% CL) experimental feeds with varying levels of cottonseed protein concentrate by substituting fishmeal were prepared and a feeding experiment was conducted for 10 weeks.

At the end of the feeding trial, all fishes were starved for 24 h and final body weight was recorded. Randomly, four fishes from each replicate were anesthetized with clove oil for blood and serum collection.

Percent ingredient composition of the experimental feeds incorporating cottonseed protein concentrate

Ingredients	CON	25CSP	50CSP	75CSP	100CSP
Cottonseed Protein Concentrate	0	7.15	14.3	21.45	28.6
Soya flour	12	12	11.5	11.5	11
GNOC	20.2	20.27	20.27	20	20
MBM	5	5	5	5	5
DORB	5.3	5	5.36	5.4	5.65
Fishmeal	30	22.5	15	7.5	0
Wheat flour	20	20	20	20	20
Fish oil	1	1.5	1.5	1.75	2.15
Sunflower oil	1	1	1.3	1.5	1.5
Vitamin mix	1.5	1.5	1.5	1.5	1.5
Mineral mix	1.5	1.5	1.5	1.5	1.5
SMB+BHT	0.2	0.2	0.2	0.2	0.2
Methionine	0.35	0.38	0.42	0.45	0.5
Lysine	0.2	0.25	0.4	0.5	0.65
Vitamin C	0.25	0.25	0.25	0.25	0.25
Lecithin	0.5	0.5	0.5	0.5	0.5
Dicalcium Phosphate	0.5	0.5	0.5	0.5	0.5
Sea weed+ Neem+ Fish wort	0.5	0.5	0.5	0.5	0.5

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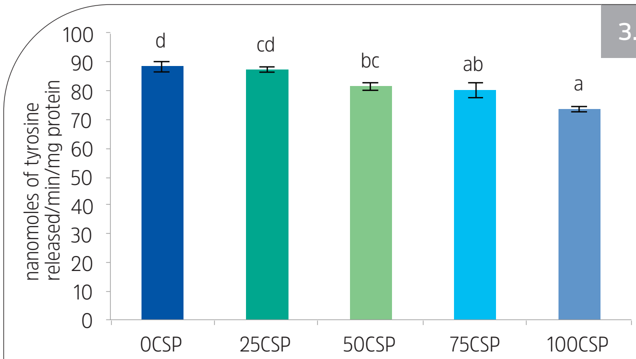

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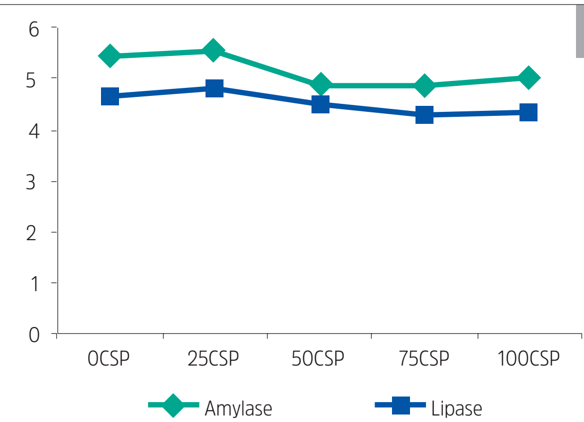


1. Cotton seed meal
2. Dried cotton seed protein concentrate
3. Protease activity in pompano fed cotton seed protein concentrate
4. Amylase and lipase activity in pompano fed cotton seed protein concentrate. Units of a-amylase is nanomoles of maltose released/min/mg protein. Units of lipase is nanomoles of pNP liberated/min/mg protein.

Tissue samples were collected from fishes and 10% tissue homogenates were prepared for digestive and metabolic enzyme analysis.

Growth performance

The growth parameters of snubnose pompano showed significant difference among the treatments (P<0.05) and higher WG% and SGR were recorded in the 0CSP group and lowest values were registered in the 100CSP group. Better FCR was found in 25CSP group and better FE was noticed in 50CSP group.

Digestive enzymology

The protease activity showed significant difference (P<0.05) among the treatments. Among the treatments higher protease activity was witnessed in 0CSP group and the activity decreased as the level of inclusion of CSP increased. The amylase and lipase activity did not show significant difference (P<0.05) among the treatments. However, higher activity was witnessed in 25CSP group.

Haematological responses

The haematological parameters such as WBC, RBC, MCV, MCH and MCHC showed significant differences among the treatments (P<0.05). Higher Hb, RBC, WBC and MCHC levels were registered in 25CSP group and higher MCH and MCV values were recorded in 75CSP group.

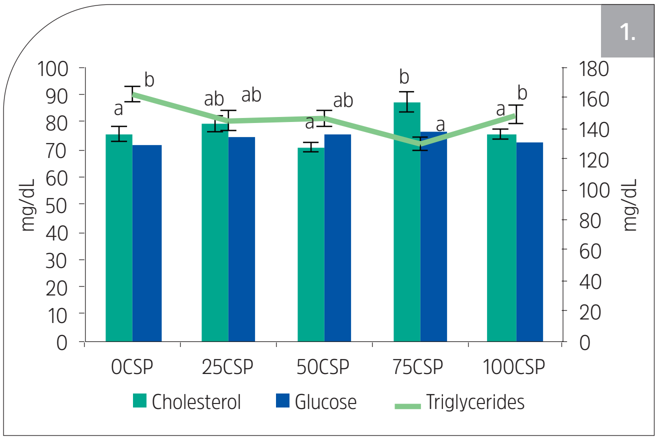
Biochemical markers

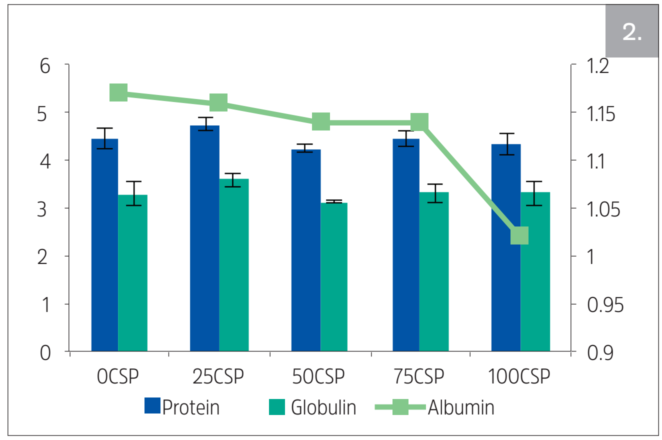
There was no significant difference in the serum protein, albumin and globulin among the treatments (P<0.05). Higher serum protein and globulin levels were witnessed in 25CSP group and higher

Growth and feed utilization indices on feeding cottonseed protein incorporated diets

Parameter	0CSP	25CSP	50CSP	75CSP	100CSP	P Value
Initial weight	3.96±0.21	4.04±0.04	4.08±0.11	4.21±0.08	4.17±0.11	0.635
Final weight	15.48±0.98	15.50±0.19	15.51±0.54	15.33±0.17	14.69±0.29	0.776
WG%	$290.57^{c}\pm3.90$	$283.53^{c}\pm3.70$	$279.82^{bc}\pm2.97$	$264.56^{ab}\pm6.21$	$252.78^{a}\pm7.01$	0.002
SGR	$1.94^{c}\pm0.01$	$1.92^{c}\pm0.02$	$1.91^{bc}\pm0.01$	$1.85^{ab}\pm0.02$	$1.80^{a}\pm0.03$	0.002
FCR	$1.90^{a}\pm0.06$	$1.84^{a}\pm0.04$	$1.86^{a}\pm0.07$	$1.95^{ab}\pm0.04$	$2.08^{b}\pm0.02$	0.035
FE	$0.53^{b}\pm0.02$	$0.54^{b}\pm0.01$	$0.54^{b}\pm0.02$	$0.51^{ab}\pm0.01$	$0.48^{a}\pm0.01$	0.044
PER	$0.76^{a}\pm0.02$	$0.74^{a}\pm0.01$	$0.75^{a}\pm0.03$	$0.78^{ab}\pm0.02$	$0.83^{b}\pm0.01$	0.034

The mean values in the same row with different super script differs significantly (P<0.05). The data expressed as mean ±SE; n=3.





albumin level was observed in 0CSP group. In case of serum glucose, no significant difference was observed among the treatments (P<0.05). Higher serum glucose level was observed in 75CSP group. Serum triglycerides and cholesterol levels showed significant difference among the treatments. Higher cholesterol and triglyceride levels were observed in 75CSP and 0CSP groups, respectively.

The mean values in the same colored bar/line with different super script differs significantly (P<0.05). The data expressed as mean ±SE; n=3. The levels of Albumin and Triglycerides represented in secondary axes in the graphs

There was no clear trend in the haematological responses among the different treatments. No significant difference in serum biochemical profile (protein, albumin, globulin and glucose) was observed among the treatment which indicates that the health of the fishes was not affected by CSP. Based on the growth, feed utilization and digestive enzyme profile, it is concluded that CSP can replace up to 50% of fishmeal in terms of protein content without any adverse effect on growth and feed utilization of snubnose pompano.

Black Soldier Fly Larvae (BSFL) as a fish feed ingredient and waste valorization

Bioconversion efficiency and nutritional evaluation of black soldier fly (BSF) *Hermetia illucens* larvae in different substrates

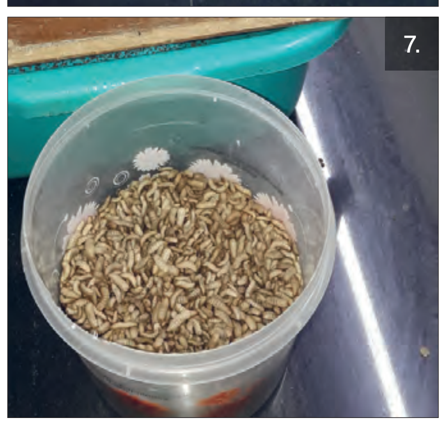
Black soldier fly (BSF) larvae are an excellent means of high value sustainable protein and lipid rich ingredients for aqua feeds due to their good nutrient profile with high protein (> 40 % on dry matter basis) and lipid (>35 % on dry matter basis) depending on the nutritional content and nature of the substrate provided. They also are a preferred nutrient bioconversion agent for organic wastes due to several attributes such as (i) fast and efficient bioconversion, (ii) non-pest nature, (iii) short lifecycle with its ability to repopulate quickly and (iv) non-fondness towards human inhabitation. In the present work, three different substrates *viz.,* vegetable waste (T1), whole fish waste (T2) and food waste (T3) were used for the evaluation of growth, bioconversion efficiency and nutritional composition of BSF larvae. 5 day old BSF larval biomass were weighed and distributed equally at the rate of 100 g in the trays provided with substrates (5.3 kg each) for a period of two weeks. The inoculation rate of BSF larvae to substrates was 1:53 w/w in all the treatments.

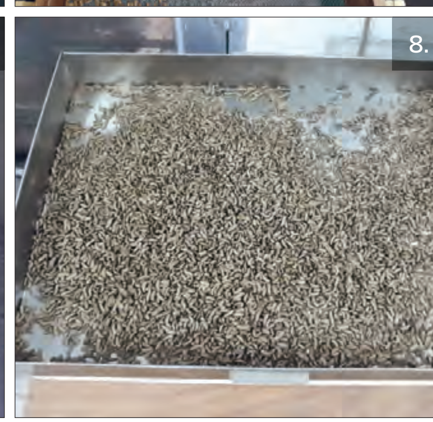
Hematological indices on feeding cottonseed protein concentrate to pompano

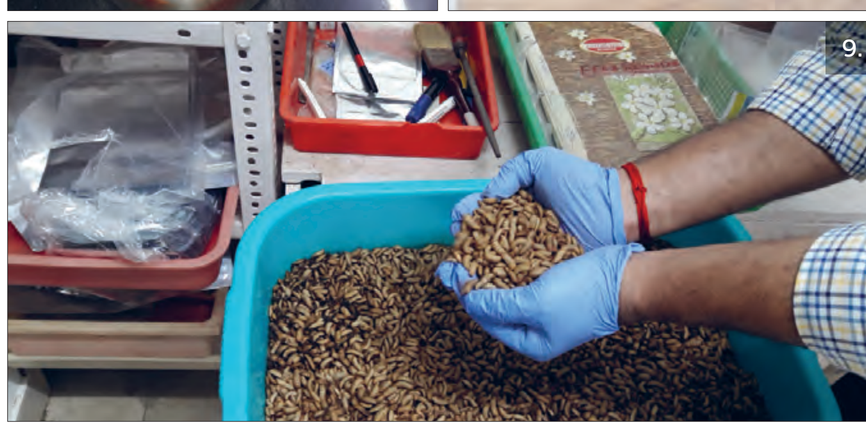
Parameters	0CSP	25CSP	50CSP	75CSP	100CSP	P Value
Hb (g/dL)	11.53 ± 0.12^{b}	11.75 ± 0.03^{b}	10.47 ± 0.29^{a}	10.40 ± 0.12^{a}	9.95 ± 0.11^{a}	0.001
RBC (10^6)	3.51 ± 0.04^{b}	3.57 ± 0.05^{b}	3.43 ± 0.03^{ab}	3.27 ± 0.07^{a}	3.33 ± 0.04^{a}	0.011
MCH (pg)	44.53 ± 0.40^{c}	43.36 ± 0.35^{bc}	42.33 ± 0.34^{ab}	45.03 ± 0.99^{c}	41.04 ± 0.40^{a}	0.005
MCHC (gHb/dL)	35.83 ± 0.43^{b}	37.33 ± 0.46^{c}	35.06 ± 0.34^{ab}	33.86 ± 0.40^{a}	34.53 ± 0.54^{ab}	0.002
MCV (fl)	122.37 ± 1.53	117.10 ± 1.36	121.07 ± 1.27	124.7 ± 3.14	117.10 ± 2.85	0.124
WBC (10^3)	5.32 ± 0.08^{bc}	6.01 ± 0.27^{c}	4.34 ± 0.28^{a}	4.55 ± 0.19^{ab}	4.83 ± 0.35^{ab}	0.006

1. Serum protein, albumin and globulin of snubnose pompano fed with varying levels of CSP
2. Serum levels of cholesterol glucose and triglycerides in snubnose pompano fed with varying levels of CSP.
3. Vegetable waste
4. Fish waste
5. 5 day old BSF larvae

6-9 Collection and processing of BSFL







Proximate composition of BSF larvae reared in different substrates (% DM basis)

Substrates	Crude Protein	Ether extract	Crude fibre	Total ash	Acid insoluble ash	Nitrogen free extract	Dry matter
Vegetable waste (T1)	49.79±0.14[a]	34.79±0.02[a]	1.02±0.02[b]	10.50±0.20[b]	0.71±0.01[b]	3.18±0.28	29.58±0.51
Fish waste (T2)	52.44±0.29[b]	36.27±0.27[b]	0.59±0.01[a]	6.06±0.07[a]	0.74±0.02[b]	3.90±0.21	30.60±0.53
Food waste (T3)	49.75±0.15[a]	38.45±0.22[c]	0.55±0.02[a]	6.51±0.31[a]	0.58±0.01[a]	4.14±0.53	29.01±0.50

Note: The values bearing different superscripts in the same column indicate statistical significance ($P<0.05$), mean± SE, n=3.

Highest growth and total bio mass of the larvae were observed in T2 followed by T3 and T1. The total biomass gain % of the larvae in T1, T2 and T3 were 467±6.08, 1616±13.20 and 1288.33±19.06 (%) respectively and differed significantly *(P<0.05)* among the treatments. The average biomass yield of larvae was 0.13, 0.42 and 0.34 in T1, T2 and T3 respectively. Bioconversion efficiency was highest in T2 and lowest in T1. The nutritional composition of the larvae exhibited significant differences among the treatments. The highest crude protein content in larvae was found in T2 (52.44± 0.29, % DM basis) followed by T1 and T3. The lipid content (% DM basis) of larvae in T1, T2 and T3 were 34.79±0.02, 36.27±0.27 and 38.45±0.22 respectively.

Standardization of the method for partial defatting of BSF larvae meal

Since the BSFL meal is also a rich source of lipids with around 35% fat on DM basis, there are certain issues like rancidity and oxidation during long term storage. A process was optimized for the partial defatting of BSFL meal by modifying a patented protocol of Steinkraus (1985) which is used for the defatting of soybean meal. After defatting, a dry matter yield around 70%, with a crude protein content of 53.9% and crude lipid content of 9.65% was obtained, so that the shelf life can be improved.

Upscaling the system for production of BSFL and Compost from food waste

The existing unit which could handle around 30 kg of organic waste per month was upgraded to handle organic waste to the tune of 250 kg per month, which is sufficient to completely process the food waste generated from the departmental canteen of ICAR-CMFRI, Kochi.

Food waste from the departmental canteen (average daily weight 7.77 kg) was used as the raw material for composting by BSF larvae. It was weighed and mixed with coir pith powder (16: 1 w/w of food waste: coir pith) to reduce the moisture content to around 60% and put into the digestion unit around 15.00 h on a daily basis.

Most of the components used for assembling the whole unit were discarded-reused materials. The different components include:

A Digestion cum composting unit (DCCU of 1-ton capacity FRP tank (dimensions; 200cm x 76cm x 77cm) was modified to facilitate composting by BSF. A partition was made at the 3/4th length at the rear end of the tank with a slit opening below which facilitates the movement of frass (excreta of insect larvae) and pre-pupae to get collected in that chamber.

Initially this tank was filled with 5 cm thick layer of coir pith at the bottom to facilitate absorption of moisture. The daily food waste – coir pith mix is put at the front end of this chamber for consumption by the larvae. Initially BSF larvae (5 days old) were inoculated into the tank. Later on, they were added regularly on a weekly basis from the battery units. Larvae of different stages exist simultaneously in this chamber. Upon maturation, the larvae will move towards the adjacent chamber where it metamorphoses into pre-pupae. Both the larvae and pre-pupae can be collected from this chamber. A self-harvesting pre-pupae collection unit was also set up in this chamber. The pre-pupae were transferred to the pupal incubation unit for subsequent hatching to flies.

Complete daily food waste (Average daily weight, 7.77 kg) from the canteen can be processed in this unit. The consumable portion of the waste will be finished by the BSFL within 8-10 hours. Due to the fast consumption by BSFL, unpleasant odours do not emerge from this unit, since time is limited for any bacterial action. The frass of BSF undergo microbial composting mainly by anaerobic digestion and can be collected once in 2 months from this unit, which should be kept for 2 weeks in aerobic condition prior to use in order to remove the ammoniacal odour.

Battery unit for breeding, egg laying, hatching (BU) is an integrated unit consisting of a glass chamber (180cm x 60cm x 60cm) with one side covered using 0.4 mm mesh and a partition in the middle. The components of the first compartment include (a) egg laying containers with eggies, (b) containers for pupae to hatch (hatching containers) and (c) water tray (for BSF) and while the (d) trays for larval rearing (up to 5 days) kept in the second one. These larvae can be added to the DCCU on a weekly basis or be utilized for other research purposes. The glass chamber should be placed in an area with open sunlight which is the main stimulus for the breeding of flies. Mating process is usually observed between 10 am to 12.30 pm during sunny days.

Egg laying cum hatching containers with ovipositors is an integrated system made for egg laying and hatching. It consists of a small plastic container (22cm x 10cm x 10cm) with a lid on top. Moistened feed material (moisture content 60-70%) will be placed in the container for the hatchlings to survive. Eggies are facilities provided for the BSF to lay eggs. This was made by attaching a used 96 well plate on the lid in an inverted manner. This is advantageous over the commonly used corrugated card boards with regard to its long-lasting usage and easiness in cleaning and removing the debris of hatched eggs. The corrugated card board requires fresh replacement since it can't be reused. As the eggs hatch, the larvae will fall directly in to the moistened feed mix placed below the eggies.

Pupal incubation and hatching containers. In these containers, the pupae are kept for hatching into BSF. This is a dark container with holes (5mm dia) at the top for the flies to emerge out.

Water tray. Water is provided in this chamber for the flies to drink. An open plastic container is provided with a sponge to facilitate absorption of water and to prevent drowning of the flies.

Trays for early larval rearing. The early larvae (1-4 days old) are fragile and is not advisable to add directly to the DCCU. So they are initially transferred to the adjacent chamber containing trays for rearing up to 5 days using food waste-coir pith mix. Afterwards, they are transferred to the DCCU. The sides of this chamber is covered partially using vinyl stickers to allow medium entry of sunlight as larvae are photophobic.

Ant proofing system. Ants proved to be a big menace to the BSF colony since they eat BSFL, eggs and also the food waste. To prevent the entry of ants into the system, ant proofing is a must in the DCCU and BU.

Collection of advanced larvae The advanced larval stage is reached after 10-15 days of continuous feeding. For utilizing as a fish feed ingredient, larvae (white) is preferred over pupae (dark brown) due to low chitin content and more digestible protein. A unit was designed for easy collection of larvae from the DCCU. The mature larvae along with frass are put into this unit equipped with 5mm sieve. The larvae will be separated from the frass and gets collected in the glass tank below along with small sized debris. The larvae will be separated by further sieving using 3 mm mesh. The collected larvae are weighed

1. Black soldier fly (BSF)
2. BSF larvae
3. BSF eggs
4. Hatch outs (5-day old)
5. Battery unit for BSF breeding and larval rearing
6. Eggies- integrated unit
7. Water tray for BSF adults
8. Pupal incubation box

and dried in a hot air oven, cooled to room temperature and stored in air tight containers. Further processing steps include partial defatting of ground BSFL, inclusion in fish feeds and experimental trials for optimizing the inclusion levels.

Bio reactors for undigested frass. This unit is meant for the composting of undigested organic residues rich in fibre which the BSFL won't consume. Such material is collected from the digestion unit and kept in bioreactors enriched with microbes (Microbial composting medium, developed by KAU) for aerobic digestion/ composting provided with adequate moisture levels (40-50%).

Comparison of ovipositor substrates for BSF

In this study, five substrates were selected *viz.,* wooden plates, fluted card boards, 96 well microtiter plate, glass plates and bio balls to compare the rate of oviposition for a period of 3 days in the breeding chamber. The results showed that 96 well plates can also be used as a substrate like the commonly used wooden plates and corrugated card boards. 96 well plate was better as compared to glass plates and bioballs used for oviposition.

A memorandum of understanding (MoU) was signed between ICAR-CMFRI and M/s EXOCYCLE, India for collaboration on the utility of BSFL as a protein and lipid rich ingredient for formulation of fish feeds. Feeding trials in pompano using BSFL meal is in progress to evaluate the effect of BSFL in the diet of pompano by replacement of fish meal

Estimation of dietary lysine requirement of silver pompano (*Trachinotus blochii*)

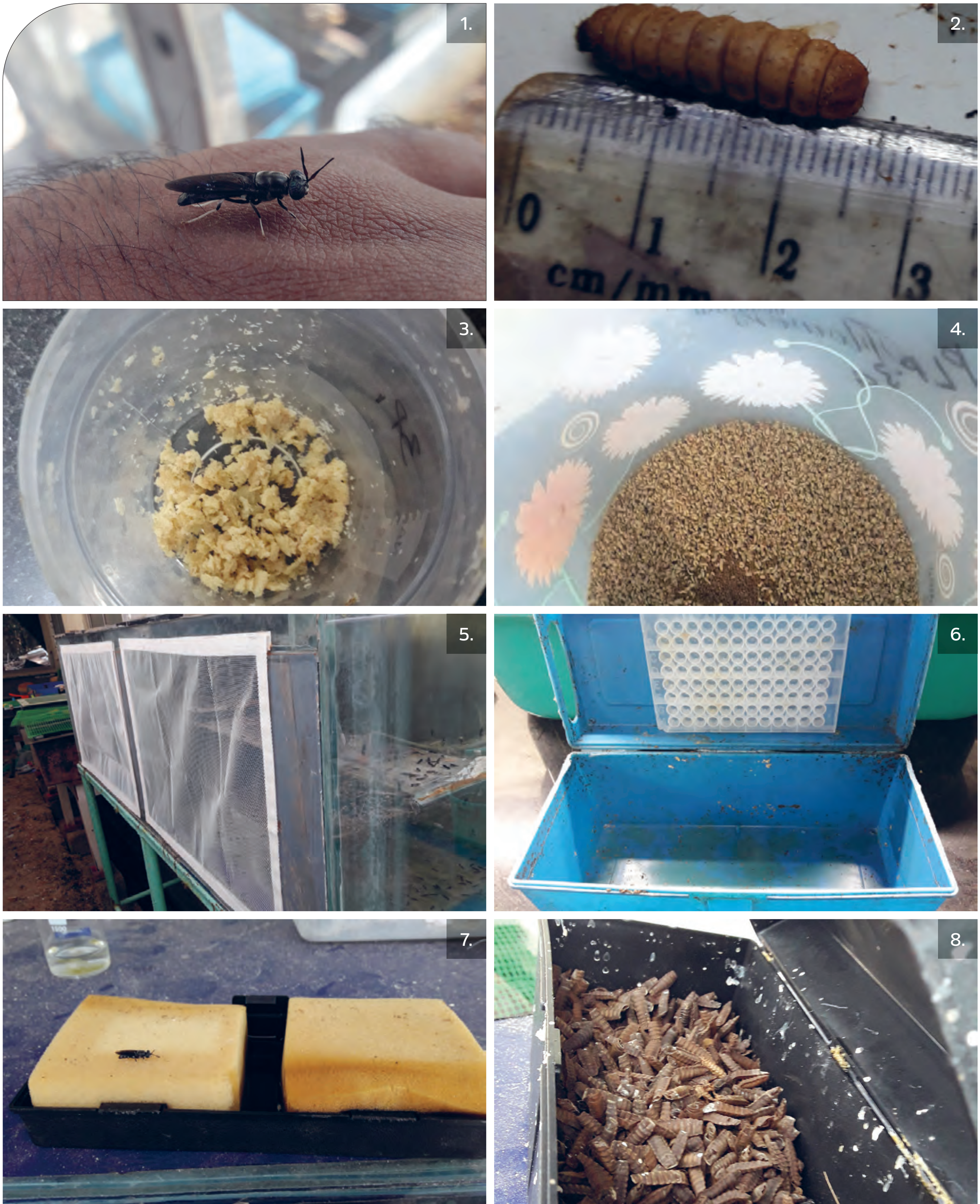
A 12-week feeding trial was conducted to quantify the dietary lysine requirement of juvenile silver pompano with an initial average weight of 6.28 g reared in indoor recirculatory system. Six treatment diets designed with isonitrogenous, isolipidic and isoenergetic diets (42% CP, 6% CL and 4.28 kcal g^{-1} GE) were formulated with graded levels of lysine (1.52, 1.85, 2.21, 2.49, 2.74 and 2.98g/100 g, dry diet). Equal amino acid nitrogen was maintained by replacing lysine with nonessential amino acid mixture. Fish were randomly stocked, in triplicate groups, in 180 L indoor rectangular glass tanks with recirculatory system and fed to apparent satiation over two feedings at 10:00 and 16:00 h

Proximate composition of the compost (%)

Dry matter	Total nitrogen	Fat	Fibre	Ash	Acid insouluble ash
58.38	2.73	0.56	1.98	28.99	6.07

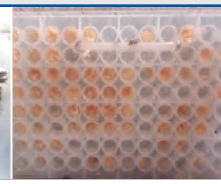
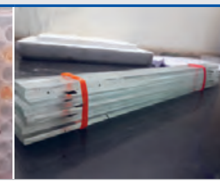
Results of the evaluation of the BSF production and composting unit for a period of 2 months

Total food waste laid (kg wet wt.)	Larvae collected (kg wet wt.)	No. of days food waste deposited	Av. waste per day (kg)	Av. larvae collected per day (kg)	Waste-larvae conversion ratio	Av. dry matter yield of larvae (%)	Total Dry wt. of larvae (kg)
334	49.149	43	7.77	1.14	6.80	29.01%	14.26


1.
2.
0
1
2
3
cm/mm
3.
4.
5.
6.
7.
8.

1. Food waste
2. Coir pith powder
3. Digestion cum composting unit
4. Ant proofing
5. Larval collection system
6. Harvested BSF larvae
7. Dried BSF larvae
8. BSF meal
9. Fish feed prepared using BSF meal
10. Bioreactor unit for frass
11. Experimental feeds
12. Experimental units for fish feeding trials
13. Signing of MoU with M/s Exocycle, India for BSF culture

Comparison of different oviposition substrates for BSF

Substrate	Wooden plates	Corrugated card boards	96 well plates	Glass plates	Bio balls
Parameters					
No. of egg masses/ day	62.33 ± 2.18^{c}	55.33 ± 1.33^{b}	62.67 ± 1.15^{c}	22 ± 1.73^{a}	18.33 ± 2.08^{a}
Weight (mg) of egg clutches	49.5 ± 1.65^{a}	50.5 ± 1.59^{b}	51.5 ± 2.29^{b}	50.9 ± 1.60^{b}	44.7 ± 1.73^{a}
Advantages	-Re-usable -Easy to collect egg	Easily available	-Re-usable -Easy egg incubation/ collection/ cleaning	-Re-usable -Easy for egg collection	Re-usable?
Disadvantages	Needs assembling	-Single use -Difficult to collect eggs	Not commonly available	Needs assembling	Difficult to clean/ collect eggs

daily during the experimental period. The results indicated that there were significant differences in growth and feed utilization among the treatments. Fish fed diets with lysine in different treatments showed high survival rate (95-100%). Maximum weight gain (WG), specific growth rate (SGR) and protein efficiency ratio (PER) occurred at 2.21% dietary lysine. The hepatosomatic index (HSI), viscerosomatic index (VSI) and crude protein content in whole body were significantly affected by dietary lysine levels. There were significant differences *($P<0.05$)* in total serum protein levels and erythrocyte count in fish fed diets with different dietary lysine levels. No significant differences were observed in the levels of serum glucose, triglycerides and creatinine levels among the treatments. In the present study, optimization of fitted quadratic regression of weight gain%, SGR, PER and FER on lysine in diet revealed that the optimum lysine requirement of silver pompano was in the range of 2.40 – 2.45% of dry diet (5.71 – 5.83% of dietary crude protein). doi:10.1016/j.aquaculture.2019.734234.

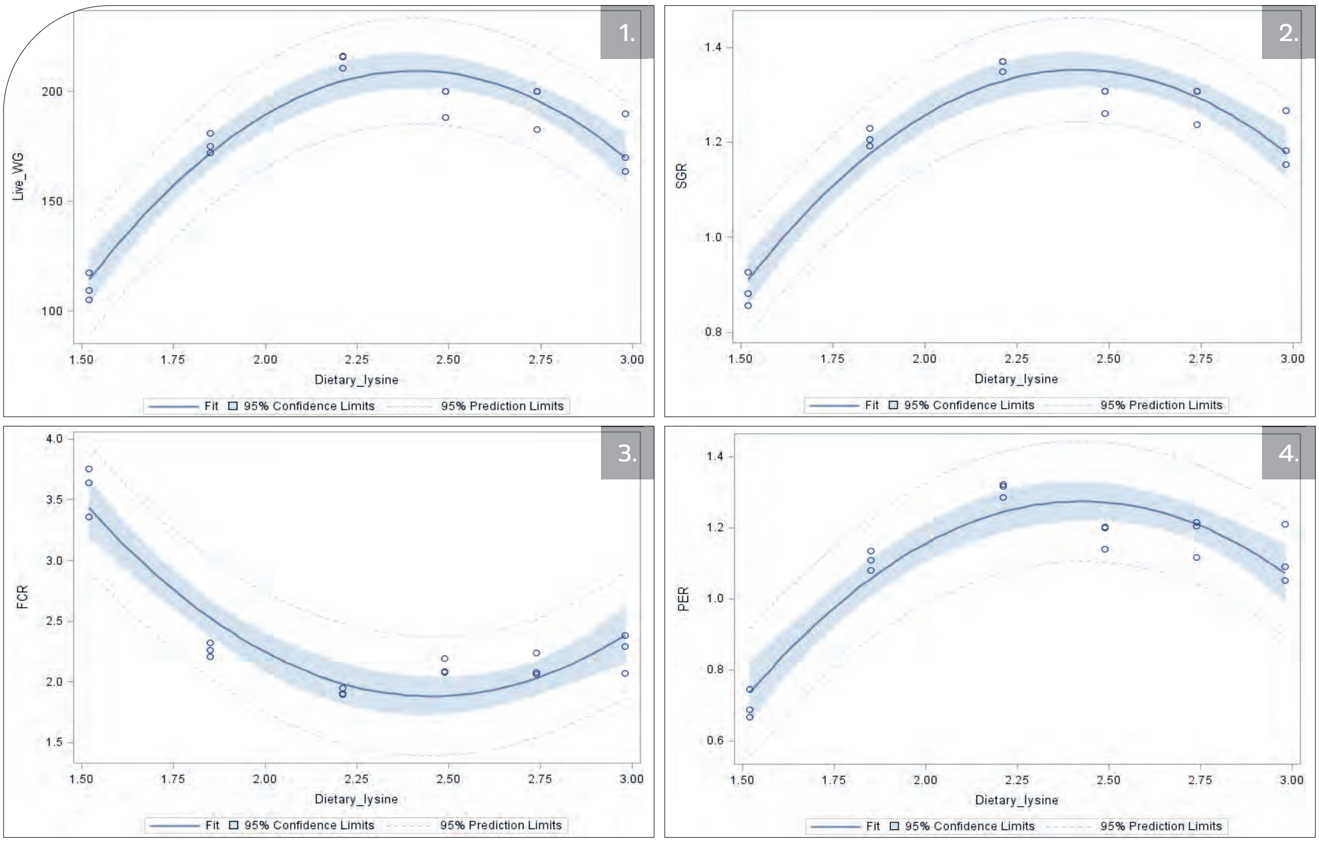
Estimation of dietary methionine requirement of silver pompano *(Trachinotus blochii)*

In this study, we optimized the dietary methionine requirement of juvenile silver pompano (average initial weight of 5.47 g). Six isonitrogenous and isolipidic diets (420 g/kg crude protein [CP] and 60 g/kg lipid) were formulated with different concentrations of methionine (5.1, 6.9, 9.0, 10.7, 13.1, and 15.2 g/kg dry diet) and a constant level of cysteine (5.3 g/kg). Fishes were randomly stocked in a re-circulatory system for a feeding trial of 90 days. After the feeding trial, significant differences ($P < 0.05$) were observed in growth parameters such as weight gain (WG), specific growth rate (SGR), thermal growth coefficient (TGC), and feed utilization indices, including feed conversion ratio (FCR) and protein efficiency ratio (PER), among different treatment groups. No significant differences ($P > 0.05$) were observed among hepatosomatic index, viscerosomatic index, muscle ratio, condition factor, serum glucose, triglycerides, and erythrocyte count. The optimization of the fitted quadratic regression for WG, SGR, TGC, FCR, and PER based on the dietary methionine level showed that the optimum methionine requirement of silver pompano in nursery phase ranged from 11.6 to 11.8 g/kg dry diet (27.6 to 28.1 g/kg dietary CP), corresponding to a dietary cysteine level of 5.3 g/kg.

Nutritional biochemistry

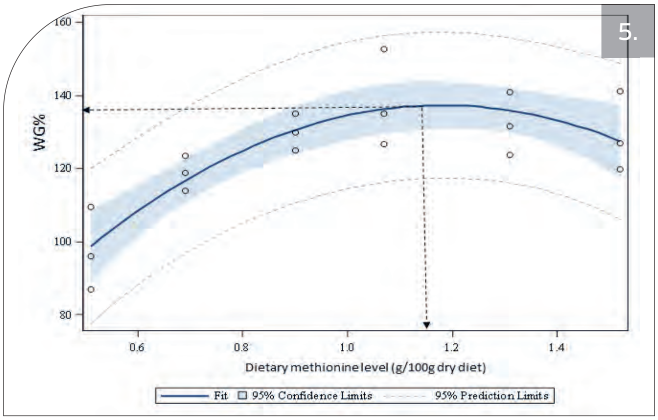
Fatty acid composition of deep sea lobster was delineated and nutritional profiling of six species of chlorophytan seaweeds were completed.

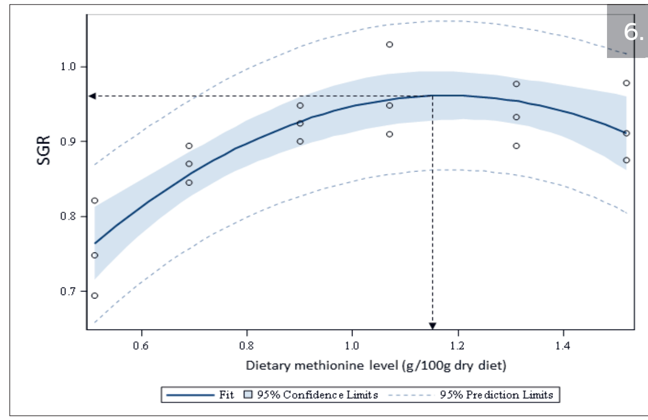
Deep sea lobsters are a predominant, unexplored species which are endowed with nutritional benefits. The fatty acid profile of the deep sea lobster, *Puerulus sewelli* indicated that high energy fatty acids EPA (10.02% and DHA 11.2%) were the major fatty acids. Higher hypocholesterolemic/



hypercholesterolemic ratio (>2.4) and lower atherogenic (<1.8) and thrombogenicity (<0.3) indices makes the lobster an ideal health food.

Energy rich constituents present in six tropical green seaweeds could be used as a potential health food. The n-3/n-6 ratio of *Ulva lactuca* (~2.14) showed the consumption of this species of seaweed would be ideal for health promoting benefits. *Chaetomorpha linum* demonstrated large proportion of macronutrients like calcium, magnesium and phosphorous. The nutrient contents also revealed that if proper processing measures were developed it would be suitable for human consumption. It is also suggested that the seaweeds taken in the current study from the family Ulvaceae could be a potential source for dietetic products and food supplements and could be a better food source than *Halimeda* species.





1. Relationship of WG% with dietary lysine levels
2. Relationship of SGR with dietary lysine levels
3. Relationship of FCR with dietary lysine levels
4. Relationship of PER with dietary lysine levels
5. Relationship of WG % with dietary methionine levels
6. Relationship of SGR with dietary methionine levels

Micro algal research

Mass culture of green alga, *Coelastrella vacuolata* belonging to the family Scenedesmaceae was standardized and nutrient profile was characterized. The effect of *C. vacuolata* meal as a fish meal replacer in the diet of Percula clown fish, *Amphiprion percula* was studied. The results revealed that *Coelastrella* meal can be utilized as a very good natural colour enhancing agent. *Coelastrella* meal can replace fish meal at the rate of 10 % to enhance the colour of the fish without affecting its growth. The growth increment of clown fish fed with *Coelastrella meal* is not on par with fish meal based diet indicating that it can be used to enhance the colour of the ornamental fish rather than growth.

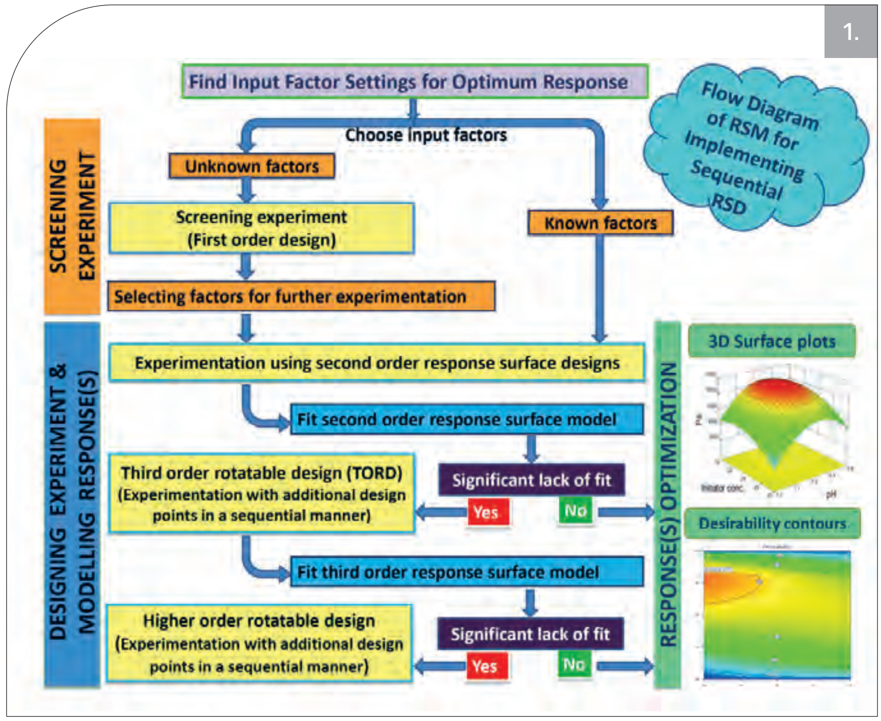
Ornamental fish feed commercialization

Revenue generated through sale of ornamental fish feeds through ATIC touched an all-time high of ₹560747/- (up to Dec 2019)

Response surface and mixture experiment methodologies for process/product optimization

(Research Project: LBS Award Project, ICAR)

Fish nutritional trials are high resource and time demanding activities. To establish a new fish feed product for the market, intensive basic research on fish nutrition as well as long field trials to verify the results are required. This implies that in addition to improving and developing new biological methodologies, it should be possible to achieve important savings in research and development costs and speed up the development process with the help of more effective experimental designs for feed formulation studies. Response surface methodology is widely used for developing and improving the quality characteristics of a process or a product through response surface model based optimization. Although the available response surface designs offer good performance and better implementation, most of the existing rotatable designs for polynomial models are symmetric (all the factors must have same levels) in nature. This usually forces the researcher



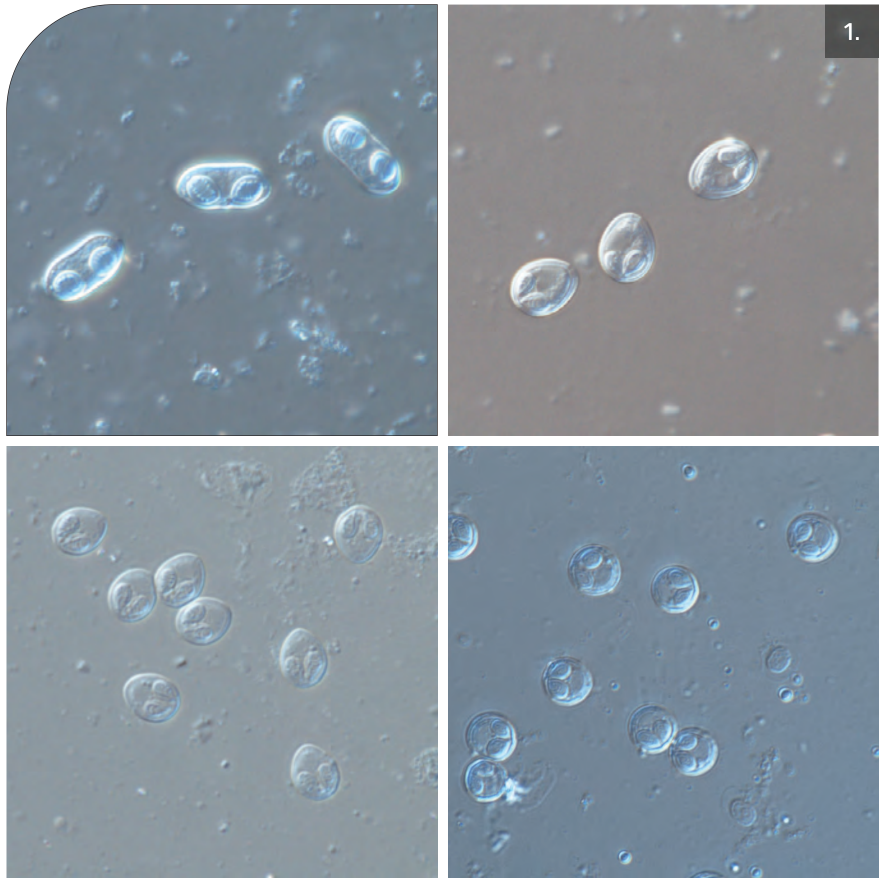
to make same levels for all the factors while carrying out the experimentation even though experiment requires different levels for different factors (mixed levels). Besides, researchers often conclude with the optimum derived based on a second order model without checking the model adequacy in establishing the input-response relationship. If the *lack of fit* of the model becomes significant (inadequate model fit), the optimum derived could lead to erroneous inference. This issue can be tackled by experimenting with sequential response surface design that accommodates mixed level input factors. With this perspective, a new class of cost-efficient mixed levels rotatable designs has been developed for sequential experimentation which allows the estimation of parameters of the second order model at first stage and further fitting of third order model with addition of few more design points. The design obtained from the proposed sequential approach will be more economical to the experimenters to obtain optimum level combination of the input factors as the design points in the first stage can be used to explore the adequacy of the second order model and if the lack of fit of the model comes out to be significant, then some additional runs can be experimented to explore third order polynomial model without discarding the responses at the initial design points.

Fish Health and Marine Bioprospecting

Research project: MBT/HLT/23

Two new parasites, a myxosporean, *Ceratomyxa xanthopterii* and didymyzoid treamtod *nematobothrium ignobili* reported

A nutraceutical product, Cadalmin™ AHe developed



Pathogen profiling in finfishes

Myxosporean infections in fishes

Infections with myxosporeans were reported in 189 of 351 fishes screened. Myxosporeans belonging to eleven genera namely, *Myxobolus, Ceratomyxa, Myxodavisia, Pseudalatospora, Sphaerospora, Sphaeromyxa, Ellipsomyxa, Auerbachia, Henneguya, Ortholinea* and *Zschokkella*, were recovered. Prevalence of infection ranged from 14.0% to 100% while the overall prevalence stood at 53.8%. In marine ornamentals, the prevalence of myxosporean infections ranged from 25% to 100.0% with an overall prevalence of 53.6%.

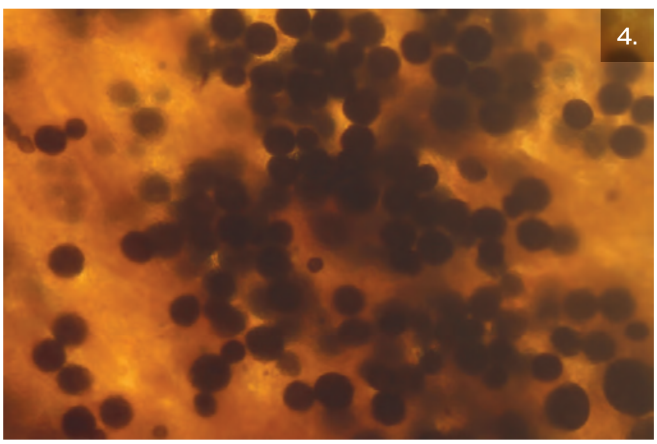
A species of myxosporean belonging to the genus *Ceratomyxa* infecting the gall bladder of *Acanthurus xanthopterus* collected from the South west coast of India was studied in detail. Morphology, morphometry, and molecular and phylogenetic analysis indicated it to be a new species and has been reported as *Ceratomyxa xanthopteri* n. sp.

A new species of didymozoid trematode was recovered from the pericardial region of *Caranx ignobilis*. Morphological characters placed the parasite under the genus *Nematobothrium*. Molecular characterisation was done using ITS1-5.8s-ITS2 region and the resulting 1237 bp sequence was submitted to GenBank. Based on the morphological, morphometric and phylogenetic studies the parasite has been described as *Nematobothrium ignobili* n. sp.

A new species of trematode was described from the emperor angel fish, *Pomacnthus imperator* from the Gulf of Mannar. Based on morphology and morphometry, the parasite was identified as *Paradiscogaster mannari* n.sp.

The life-cycle study of *Tenui proboscis keralensis* was attempted by screening the possible hosts (*Scatophagus argus* and *Lutjanus argentimaculatus*) for intermediate hosts/ infective stages. Cystacanth stages were recovered from the stomach wall and attached mesenteries of juvenile *L. argentimaculatus* and was confirmed using molecular techniques. Molecular studies on amphipods (*Jassa* sp. and *Melita zeylanica*) collected from the gut contents of the fish indicated that these could act as intermediate hosts of *T. keralensis*.

Pathogen profiling revealed the presence of various parasitic infections. *L. calcarifer* was infected with *Argulus. quadristriatus*, *Diplectanum* sp., marine leeches, helminth worms and isopods. *Amyloodinium ocellatum* was reported from *Trachinotus blotchii*



1. Myxsosporean infections
2. Larvae of *Echinocephalus overstreeti*
3. Octolasmis sp. infestation on the gills of crab
4. Hypnospores of *P. beihaiensis* in *Mytella strigata*

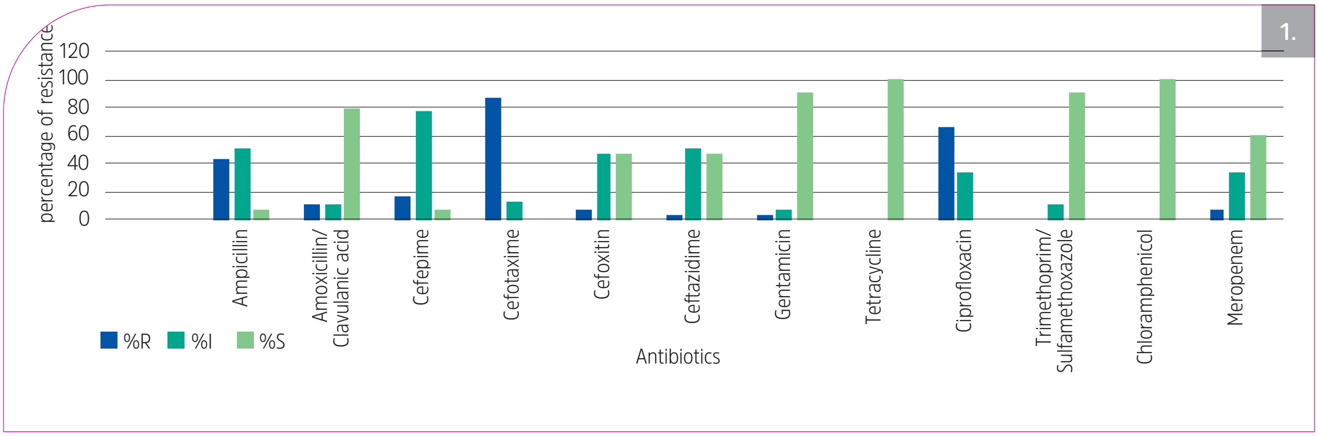
and *Rachycentron canadum*. Infection with *Oodinium* sp. infecting the skin and gills of marine ornamentals was reported from Vizhinjam. Infestations with *Cymothoa* sp. were reported from *Rastrelliger kanagurta*. Infections with the larvae of *Echinocephalus overstreeti* and *Caligus* sp. were observed in *Acanthopagrus berda* at Karwar. Infestation with the monogenean parasite, *Neobenedenia* sp. was reported from cage cultured *T. mookalee* from Visakhapatnam.

A study was carried out to compare the occurrence of parasites in cage farmed and wild fishes at Karwar and a total of 638 fish samples were examined. Parasitic prevalence (PFI: 67%) has been found to be the highest in cage farmed fishes in the month of November, 2019 followed by July (PFI: 14%) and December, 2019 (PFI: 10%). In wild fishes the prevalence was almost uniform during the period.

Pedunculate Barnacles, *Octolasmis* sp., have been reported from the gill, carapace and legs of *Portunus pelagicus*, *Charybdis lucifera* and *Scylla serrata* from the coastal waters of Karnataka.

Disease investigations in shellfishes

Post larvae of *Penaeus monodon* and *P. indicus* collected from different hatcheries in Kerala were screened for the presence of white spot virus. All the samples were white spot negative.



Disease investigations in bivalves

Infections with the OIE listed pathogen, *Perkinsus olseni* was observed in most of the bivalve samples examined. Infections with *P. beihaiensis* were also recorded. Infections with *P. olseni* and *P. beihaiensis* were also reported from the invasive bivalve species, *Mytella strigata* collected from various localities in Kerala.

Bacterial infections

Prevalence and characterization of *Vibrio parahemolyticus* in the black clam, *Villorita cyprinoides* from the southwest coast of Kerala.

Out of 158 samples of whole tissue of clams, 30 isolates of *V. parahemolyticus* (VP) were obtained indicating a prevalence of 18.9%. The bacteria were confirmed by biochemical and molecular tools using *tlh* gene as a marker. The physiological tolerance screening revealed that all the isolates grew at 42 °C, no growth was seen with 0 and 10% salt, grew well with 3, 6 and 8% NaCl supplementation. Antimicrobial susceptibility analysis indicated that 43.3% isolates were resistant to Ampicillin, 86.7% to Cefotaxime, and 66.7% to Ciprofloxacin; all the isolates were sensitive to Tetracycline and Chloramphenicol, 90% were sensitive to Gentamycin and Trimethoprim/ Sulfamethoxazole, and 80% were sensitive to Amoxicillin/Clavulanic acid. Out of 30, seven isolates had a MAR index of more than 0.2 indicating high risk of contamination.

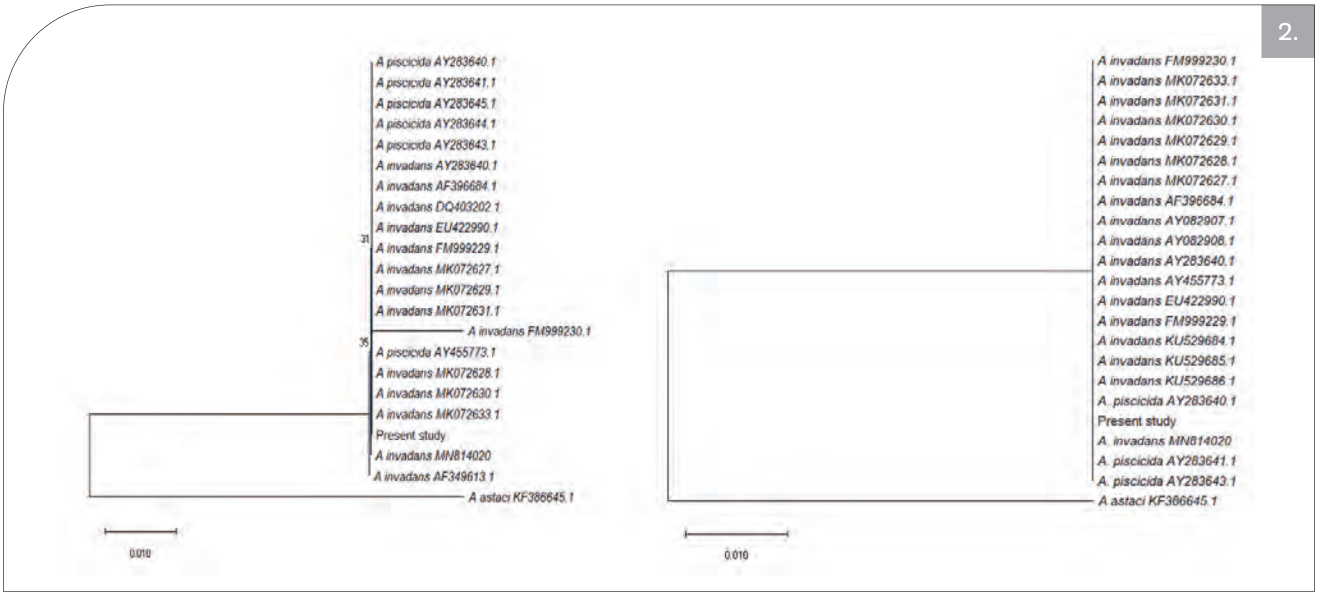
The virulotyping of all the 30 isolates revealed that only one isolate pocessed *trh* gene, while none had *tdh* gene; all the isolates were positive for T3SS1 genes, namely Vp 1669, Vp1670, Vp1686, and Vp1689; while all of them were negative for T3SS2α and T3SS2β. Enzymatic analysis revealed that all the isolates were positive for cellulose, phospholipase, amylase, DNAse, gelatinase, caseinase and lipase.

Molecular epidemiology of *Aphanomyces invadans* involved in Epizootic Ulcerative Syndrome (EUS) outbreaks across different countries was studied based on internal transcribed spacer (ITS) regions of rRNA marker. Initially, ITS regions of *A. invadans* involved during EUS outbreak causing heavy mortality among estuarine fishes of Kerala, India during 2018 and another isolate involved in EUS outbreak from fresh water aquaculture farms of Kerala were amplified and sequenced. The related sequences were retrieved from NCBI database. Phylogenetic analysis showed a high degree of genetic homogeneity in both ITS regions and were clustered together.

Sequence identity was 95.5%-100% and 98.9-100% in ITS1 and ITS2 regions respectively, suggesting that that ITS2 is more conserved than ITS1. Results showed that *A. invadans* represent a slowly evolving group regardless of causing EUS outbreaks in fresh/estuarine environments and the same clone of fungus has spread all over the world over the period of 18 years.

Genetic analysis of non-ribosomal peptide synthetase (NRPS) genes in haemolymph microbes of marine crabs was performed. Bacterial strains belonging to 5 different species were found to have NRPS gene. *In-silico* analysis showed two new putative adenylation domain signatures from phylum Firmicutes. Phylogenetic analysis showed that there was no clustering of microbial NRPS 'A' domains based on their bacterial phylum; suggesting the possibility that phylogenetically distant microbes can harbour similar types of NRPS genes. The study indicates that marine crab haemolymph microbiota is an unexplored niche for novel NRPS genes and natural products.

2.



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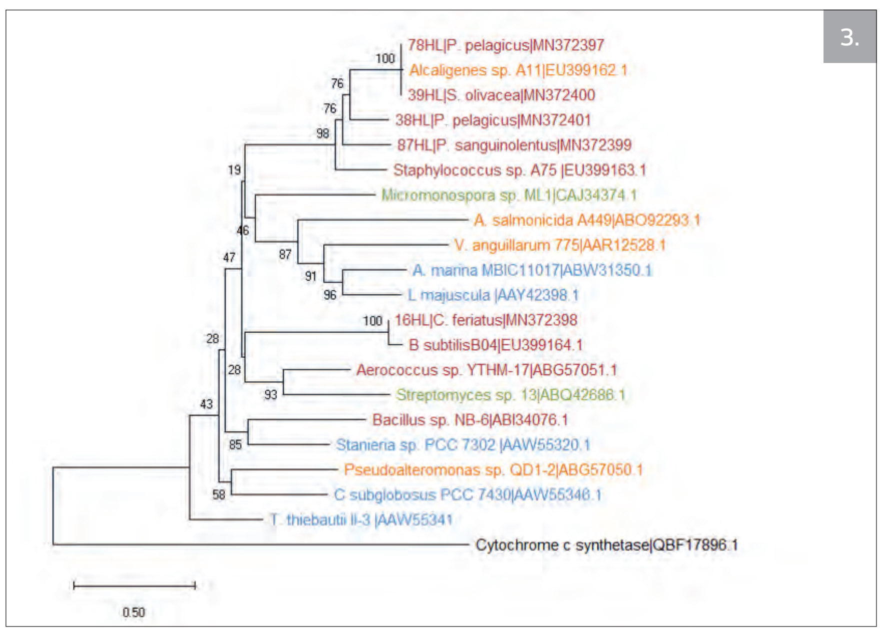
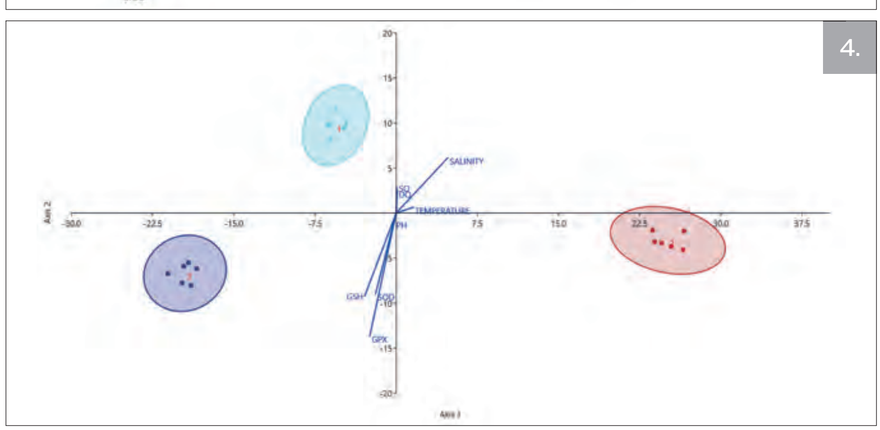


1. Antibiotic susceptibility pattern
2. Phylogram based on ITS 1 and ITS 2 of A. invadans isolates
3. Phylogram based on NRPS domains
4. Discriminant analysis of antioxidant profiles

4.



Antioxidant profiles in the haemolymph of Asian Green lipped Mussel (*Pernaviridis*) were studied to understand the environmental response of antioxidant systems. Different hydrographic characters like salinity, temperature, pH and dissolved oxygen and major biomarkers of oxidative stress like GSH (reduced glutathione), GPx (glutathione peroxidase) and SOD (superoxide dismutase) were analysed in three different time points, with significant difference in hydrographical parameters.

Results showed that profiles of all studied components were influenced

Sample comparison	No. of genes Up Regulated	No. of genes Down Regulated
Mantle Control vs Mantle Heat Stress	677	449
Mantle Control vs Mantle pH Stress	521	356
Mantle Heat Stress vs Mantle pH Stress	359	477

to a major extent by the inhabiting conditions, and synchronised action of these AOS maintained stable levels of oxidative metabolism. Further, concomitant variations in AOS levels could not be attributed to any single environmental factor. Discriminant analysis indicated a high degree of separation in sampling points with respect to hydrographical parameters as well as antioxidant bio indicators studied. Linear mixed model analysis showed that GSH has the potential to be used as an early biomarker for oxidative stress in *P. viridis*, especially when there is a gradual shift from normoxic to hypoxic conditions in its residing environment.

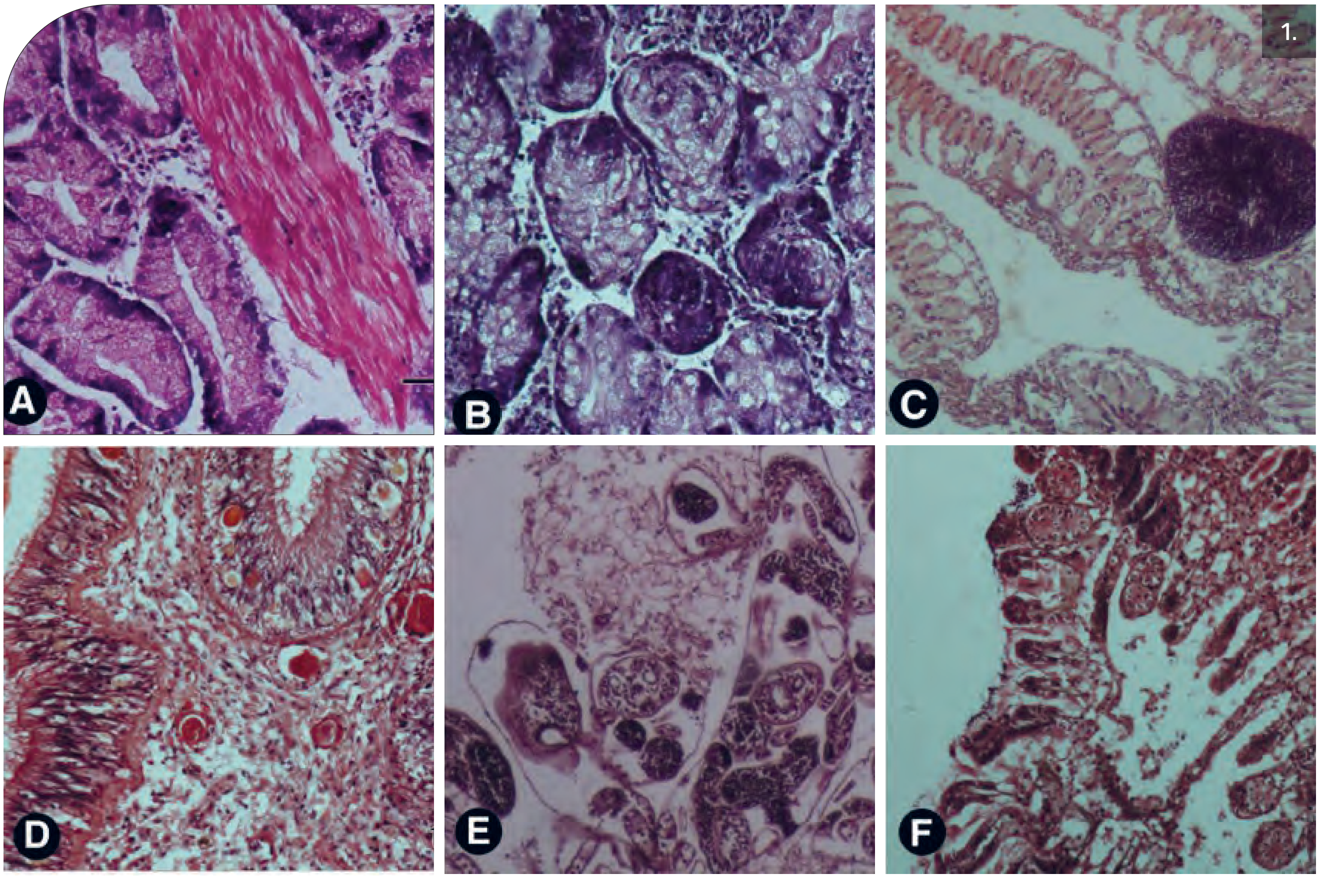
Indexing histological lesions in the digestive gland and gills of marine bivalves to develop indicators for assessing environmental quality was carried out. Clams (*Paphia malabarica*), mussels (*P. viridis*) and oysters (*Magallana bilineata*) were collected from five sites and examined histologically. The observed pathologies included, fibrous tissue proliferation in the inter-tubular area of digestive diverticula; necrotic and vacuolated tubules with numerous haemocytes infiltrating the inter-tubular tissue of the digestive gland; haemocytic nodules in the gills; infestation with Apicomplexa-like organisms; larval trematode infestation in the digestive gland and nematopsis-like protozoa showing oocysts in the gill tissues. The histopathological indices in marine bivalves from south-west coast of Kerala was lower, indicating less impact by environmental quality.

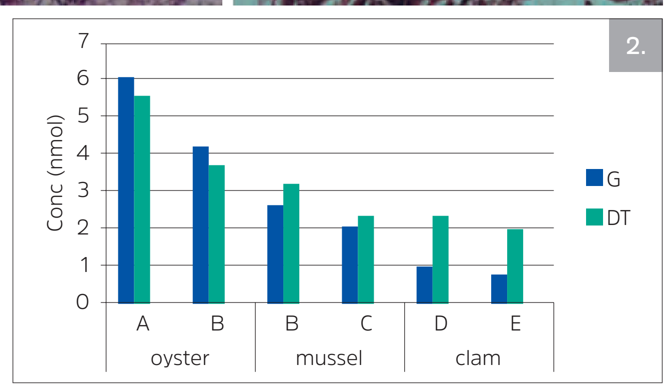
Quantification of MDA (malanodialdehyde) as biochemical marker of oxidative stress. Lipid peroxidation was measured in the gills and digestive diverticula of three distinct commercially important bivalve species collected from five sites along the Kerala coast during monsoon (October – November 2019) by evaluating malanodialdehyde measurements. The results indicated that the digestive gland and gills are active in generating oxidative stress which can be used as biomarkers of pollution. The concentration of MDA measured in the gills and digestive gland ranged between 0.80-6.08 nmole. Higher and lower concentrations were noted in the gill homogenates of oysters from Dalavapuram and clams from Periyar, respectively.

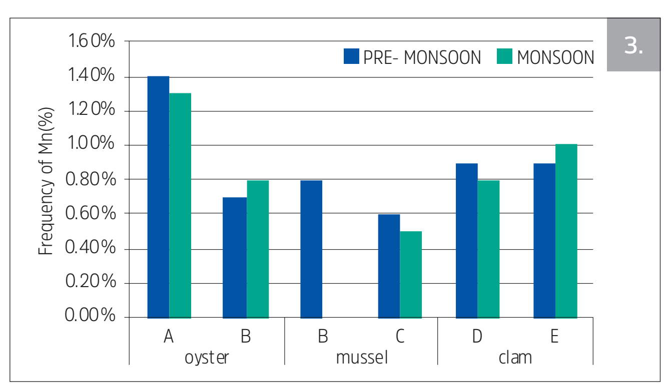
Detection of nuclear abnormalities like micronuclei (MN) in bivalve gill cells. MN are small, intra cytoplasmic chromatin masses that are the result of chromosomal breakages throughout cell division, indicative of genotoxicity. The micronuclei frequency varied in bivalves from 0.5-1.4%. A low level of micronuclei was observed in mussels collected from Sathar Island during monsoon. Comparatively increased MN incidence was found in oysters from Dalavapuram. Other nuclear abnormalities like nuclear buds, apoptotic cells, bi-nucleated cells and cells with nucleoplasmic bridges were also observed.

The complete genome sequence of a virulent strain of *V. alginolyticus* isolated from infected cage cultured asian sea bass was determined. The genome size was estimated to be 5.077096 Mb. 4,639 genes were predicted from the genome of which 4,566 had significant BLASTX match.

Magallana bilineata mantle tissue transcriptome sequencing and denovo assembly was carried out to mine the set of genes which enables the oyster to survive and withstand changes in temperature and pH. A total of 30,635,118, 31,339,668 and 21,522,472 high quality paired end reads were obtained from Control, Heat stress and pH stress exposed *M. bilineata* respectively.







1. Histopathological changes observed in bivalve tissues
2. Malanodialdehyde (MDA) assay in bivalves
3. Frequency of micronuclei in bivalves

Noctiluca scintillans bloom in Gulf of Mannar resulted in 10% mortality of cobia and Pompano (growout and brooders) maintained in cages during a two week period. The cages were moved to deeper waters to avoid gill choking and fish mortality due to algal bloom. Histology of affected pompano and cobia gills revealed primary lamellar hyperplasia and secondary lamellar erythrocytosis, congestion and necrosis. Based on the histological features, the mortality might be due to acute hypoxia because of the sudden reduction in DO level and increased ammonia content.

Neoplasia

A case of fibro chondroma in gill rackers of cobia was recorded. Appeared as a hard, red to pinkish, cauliflower-like growth, compressed over the gill rackers. There was no metastasis and secondary growth in other external and internal organs. Histologically, fibrous connective tissue and fibroblast proliferation with abundant collagen was observed above the gill arch. The cartilaginous structure was also admixed with the fibrous connective tissue. The presence of intracytoplasmic inclusion body indicated a viral origin.

In cobia brood stock, a single case of chondroma, a benign cartilaginous tumour was recorded at the caudal fin region, measured 7.6cm L x 3.2cm. Hard in nature, cut section of the portion showed pinkish cartilaginous mass. Histologically, the mass has been over grown from below the dermal layer and extended upto the epidermal layer. The stratum compactum layer was totally replaced by the over grown cartilaginous cells and were devoid of blood vessels. Fibroblast proliferation was also observed around the cartilaginous structure. There was no metastasis and malignant features. Based on the histological features, it was identified as cartilaginous chondroma.

Nodular growth on the skin of wild caught Shark was studied in detail. The tumour mass was firm and the cut surface of the tumour mass had a solid white appearance. Histopathology using routine staining and special staining with Masson's Trichrome revealed that fibroblasts were arranged with a characteristic wave and spindle nucleus with variable cellularity with some areas more collagenized than others. Interspersed between cells were eosinophilic collagen fibres. The tumour was found to be a Fibroma.

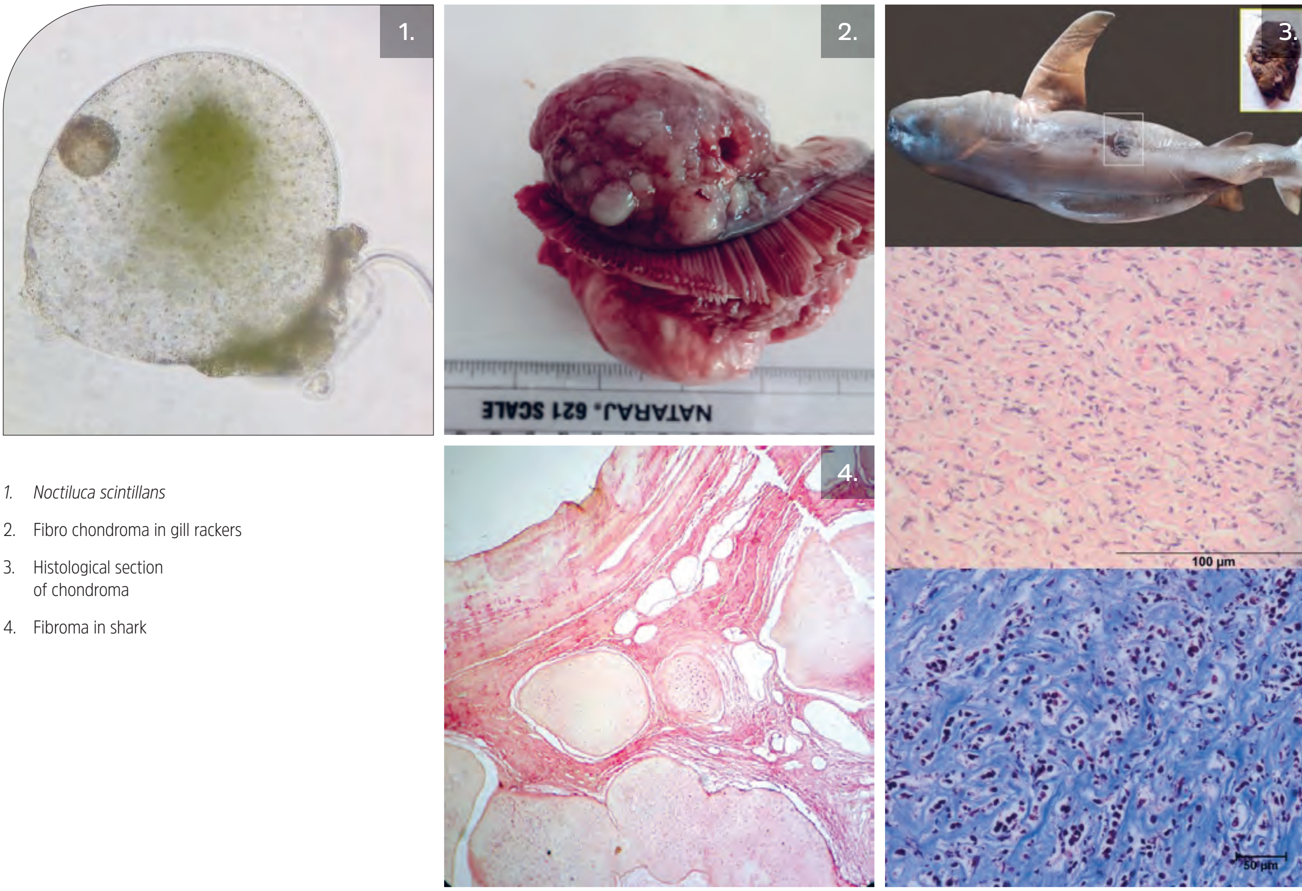
Health management

A pilot study was undertaken to study the *in-vitro* and *in-vivo* analysis of fucoidan as a biodegradable adjuvant. Fucoidan was extracted from brown algae *Sargasum wightii*. The *in-vitro* adhesion study with inactivated bacterial antigen (*V. alginolyticus*) is progressing.

Fin rot in fishes was treated using a combination of synergistic antibiotics, Gentamicin (2 ampules) + ciprofloxacin (2) in 1000 litres of water, two times daily (10am & 4pm) after water exchange, for five days. Adequate aeration was provided and water temperature maintained at 26-27 ° C.

Oral medication using Praziquantel (@ 2.4, 3.6 and 4.8 g/kg of feed, twice daily at @ 2% body weight per day for 10 days) was evaluated for controlling *Neobenedenia* infestation in pompano. The study showed that Praziquantel (@ 3.6 g/kg feed) for 10 days could control the infestation successfully.

Provided decision supports for farmers during disease outbreaks. Samples were collected for diagnosis based on standard guidelines. Detailed anamnesis was collected in each case. Water quality analyses were conducted to check for deviations from the normal



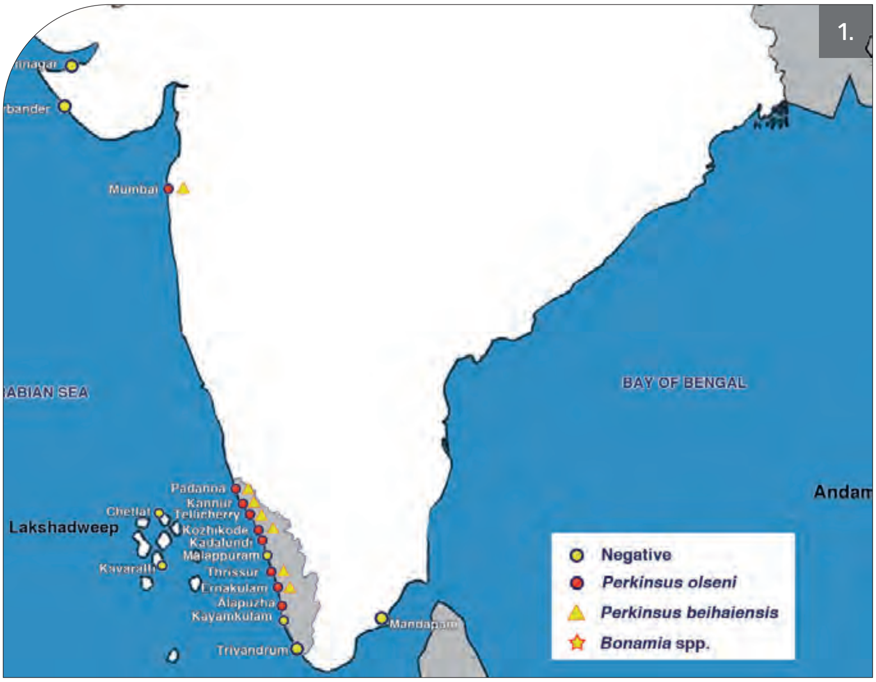
1. *Noctiluca scintillans*
2. Fibro chondroma in gill rackers
3. Histological section of chondroma
4. Fibroma in shark

limits. Further, bacteriological, virological and mycological analyses of blood and tissue samples were performed. Based on the definitive diagnosis, appropriate management strategies (preventive and remedial measures) were recommended.

National Surveillance Programme for Aquatic Animal Disease (NSPAAD)

Under the National Surveillance Programme for Aquatic Animal Diseases, regular screening of wild and farmed bivalves for OIE listed pathogens, *Perkinsus olseni*, *Bonamia ostreae* and *Marteilia refringens* were carried out along the east and west coasts of India.

A total of 988 wild bivalve samples belonging to 12 species were collected and screened. *P. olseni* was observed in *Perna viridis, P. indica, Pinna bicolor, Saccostraea cucullata, Paphia malabarica, Geloina bengalensis* and *Mytella strigata. P. beihaiensis* was observed in *P. viridis, P. malabarica, G. bengalensis, Modiolus modiolus, S. cucullata* and *M. strigata.* A total of 708 farmed bivalve samples were screened during the period. *P. olseni* was observed in farms in all the districts except Calicut. Mixed infection with *P. olseni* and *P. beihaiensis* was observed in *P. viridis* from Kasaragod, Kannur, Thrissur and Ernakulam. Bivalves from Gujarat and Tamil Nadu were free



from *Perkinsus* infections. Infections with *Marteilia* and *Bonamia* were absent in the screened populations.

All India Network Project on Fish Health

Information regarding the usage pattern of drugs and chemicals in aquaculture was collected through a questionnaire based survey. The results indicate that drugs/ chemicals are not generally used in farms in Kerala. An economic loss assessment study based on loss/mortalities in mussel farming in Kasaragode district was carried out. The results indicate that during the period farmers obtained good returns. Screening of imported marine ornamental fish for OIE listed pathogens was carried out and all the samples were negative.

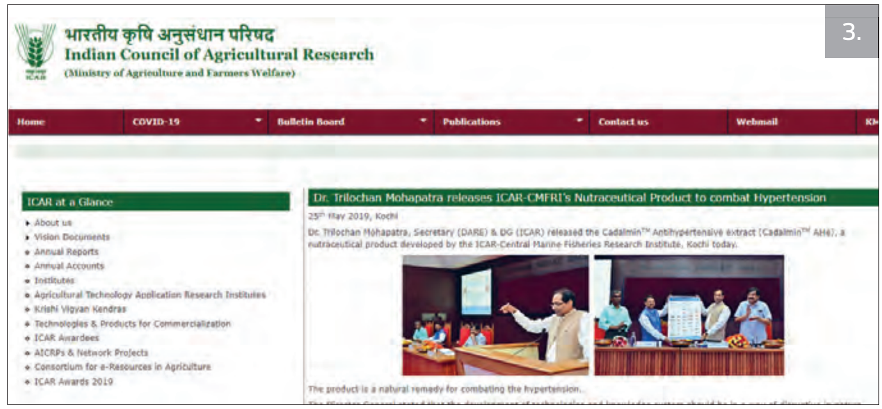
ICAR-Consortia Research Platform on Vaccines & Diagnostics:

Studies on the development of vaccine against vibriosis is progressing. Challenge studies in Asian sea bass immunized with formalin killed *V. alginolyticus* with Aluminium Hydroxide adjuvant was carried out. To evaluate vaccine efficacy, fishes from vaccinated and control groups were challenged with an intraperitoneal injection containing 0.1 ml bacterial suspension of *V. alginolyticus* (1×10^4 CFU per fish). Challenge trials were conducted at 3 and 6 weeks post infection and all experiments were run in duplicate. Cumulative mortalities of challenged fish were recorded and relative percent mortality (RPS) was calculated. After 6th week challenge studies, significant ($p<0.5$) results were obtained in the vaccinated seabass fingerlings as compared to the control. The first trial with a single dose of immunization gave protection with 80% relative percentage of survival. In the 2nd trial where booster immunization was given after 21 days, the relative percentage of survival improved to 90%.

Bioprospecting

Nutraceutical to combat hypertension: Cadalmin^{TM} Antihypertensive extract (Cadalmin^{TM}AHe) from seaweeds

Cadalmin^{TM} Antihypertensive extract (Cadalmin^{TM} AHe), a nutraceutical product developed by ICAR-Central Marine Fisheries Research Institute, as a natural remedy for hypertension, was released by Dr. T. Mohapatra, Director General, Indian Council of Agricultural Research in the presence of Dr. Joykrushna Jena, Deputy



1. Map showing collection sites
2. Vaccinating sea bass
3. Dr. T. Mohapatra, Director General, Indian Council of Agricultural Research, releases ICAR-CMFRI's nutraceutical product to combat hypertension

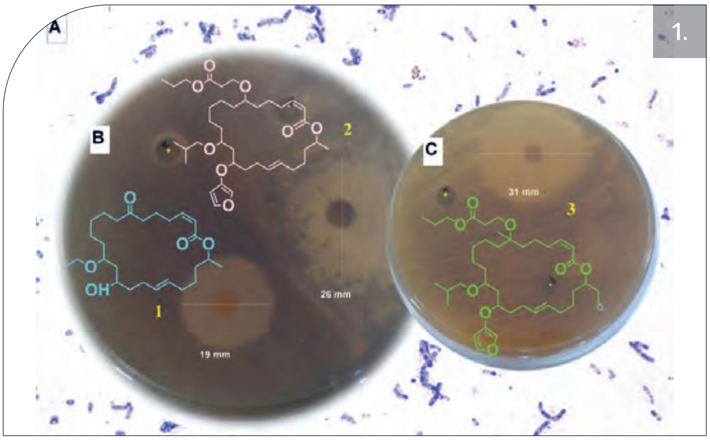
Director General (Fisheries and Animal Sciences), Indian Council of Agricultural Research on 25th May 2019. Bioactive pharmacophore leads from seaweeds were used to develop this nutraceutical product, which can be administered to regulate clinical indicators of pathophysiology, leading to hypertension which is one of the risk factors for strokes, heart attacks, heart failure, and arterial aneurysm, and is a leading cause of chronic kidney failure. Cadalmin™AHe blocks angiotensin converting enzyme that converts angiotensin I to angiotensin II. Decreased production of angiotensin II lowers blood pressure and prevents remodeling of smooth muscle and cardiac myocytes. The bioactive ingredients in the nutraceutical product effectively modulate the serum level of oxidative stress marker nitric oxide, lipid peroxidase and the potent vasoconstrictor angiotensin-II. Additionally, the formulation increases the serum level of vitamin E.

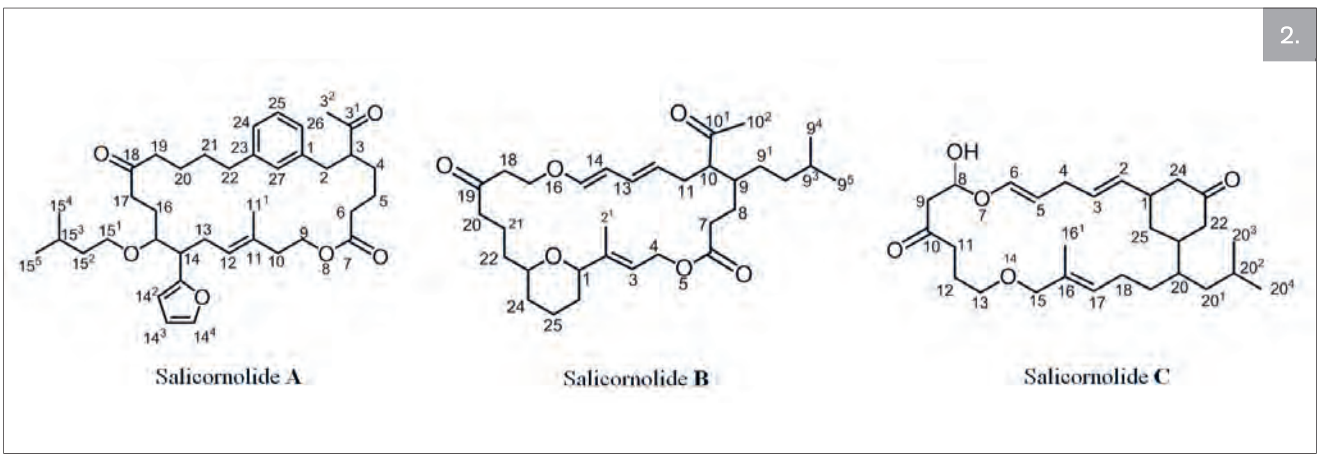
Cadalmin™AHe regulates the increased nitric oxide level in the endothelial cells. Animal model anti-hypertension experiments showed that the active principles effectively decreased the angiotensin-II levels in cadmium chloride-induced hypertension in rats. Cadalmin™ Antihypertensive extract has no side effects (LD_{50}> 4000 mg/kg BW) as proved from the preclinical and acute/long term chronic toxicity studies on experimental subjects.

Macrocyclic lactones from seaweed-associated heterotroph as prospecting anti-infective agents

Hypnea valentiae associated *Bacillus amyloliquefaciens* MTCC 12716 revealed potential inhibitory effects on the growth of drug-resistant pathogens. Three homologous members of the 24-membered macrocyclic lactone family, named as bacvalactones 1-3 bearing 13-*O*-ethyl (1), 15-*O*-furanyl-13-*O*-isobutyl-7-*O*-propyl propanoate (2), and 15-*O*-furanyl-13-*O*-isobutyl-7-*O*-propyl propanoate-7, 24-dimethyl (3) functionalities were acquired through bioactivity-guided purification.

The macrocyclic lactones displayed bactericidal activity against opportunistic pathogens causing nosocomial infections, for instance, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus faecalis* (VREfs), multidrug-resistant strains of *Pseudomonas aeruginosa* and *Klebsiella pneumonia* with MIC ≤ 3.0 μg/mL, whereas standard antibiotics,

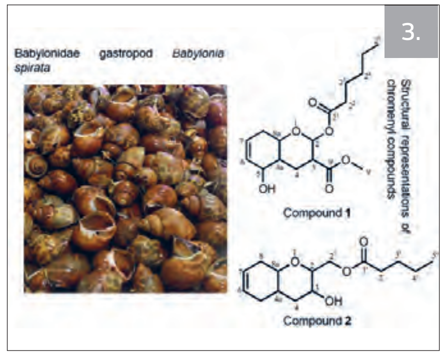


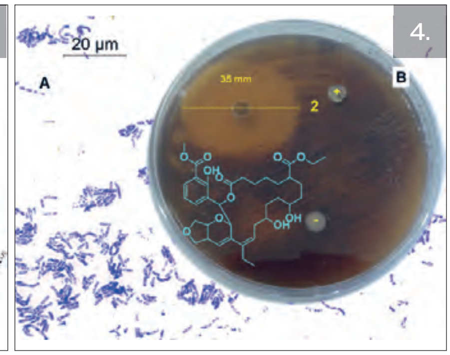


ampicillin and chloramphenicol were active only at concentrations of ≥ 6.25 mg/mL. The biosynthetic pathway of macrocyclic lactones that are generated by trans-AT polyketide synthases through stepwise extension of an acetyl starter unit by eleven sequential Claisen condensations with malonyl-CoA was established. The best binding poses for each compounds (1-3) with *Staphylococcus aureus* peptide deformylase (SaPDF) unveiled docking scores (≥ 9.70 kcal/mol) greater than that of a natural peptide deformylase inhibitors, macrolactin N and actinonin (9.14 and 6.96 kcal/mol, respectively), which supported their potential *in vitro* bioactivities.

Salicornolides A-C from *Gracilaria Salicornia* as prospective natural anti-inflammatory leads

Three salicornolides A-C bearing the carbon framework of oxabicyclo[21.3.1] heptacosa-ene-diones (A and B) and oxabicyclo[19.3.1]pentacosa-ene-dione (C) were isolated and characterised from the organic extract of the intertidal red seaweed *Gracilaria salicornia*. These natural macrolides were conformationally pre-organised ring structure providing diverse functionalities, and their potential bioactive properties led to the development of pharmacophores with anti-inflammatory properties. The first in the series of salicornolides, was named as 3-acetyl-14-(furanyl)-11-methyl-15-(15^3-methylbutyloxy)-8-oxabicyclo[21.3.1] heptacosa-11,23,25,27-tetraene-7,18-dione (salicornolide A) with the molecular formula of $C_{38}H_{54}O_6$. The second compound in the series was characterised as 10-acetyl-9-isopentyl-2-methyl-5,16,23^1-trioxa-bicyclo[21.3.1] heptacosa-2,12,14-triene-6,19-dione (salicornolide B), with the elemental-composition of $C_{32}H_{50}O_6$. The compound, (2*Z*,5*E*,16*E*)-8-hydroxy-20-isobutyl-16-methyl-7,14-dioxa-bicyclo[19.3.1] pentacosa-2,5,16-triene-10,23-dione (salicornolide C) was isolated and the molecular formula was determined as $C_{28}H_{44}O_5$.





1. Macrocyclic lactones from seaweed-associated heterotrophs
2. Salicornolide (A,B,C)
3. 2H-chromenyls from gastropod mollusc, *Babylonia spirata*
4. Oxygenated elansolid-type of polyketide spanned macrolide

Pharmacological properties of seaweeds against progressive lifestyle diseases

Seaweeds are consumed as staple food items in the cuisines of many Asian countries and are considered as essential components of a healthy diet. The pharmacological potential of 10 species of seaweeds belonging to the subclasses Dictyotophycidae, Rhodymeniophycidae, and Corallinophycidae against progressive lifestyle diseases were determined by various *in vitro* models. Among the studied species, the organic extracts of *G. salicornia* and *Padina tetrastromatica* exhibited potential dipeptidyl-peptidase-4 inhibiting activity (IC_{50} ~ 0.03 mg mL^{-1}) and angiotensin converting enzyme-I inhibitory property (ACE-I) (IC_{50} 0.12 mg mL^{-1}) compared to those displayed by other studied species. The organic extracts of *G. salicornia* and *P. tetrastromatica* also displayed significantly greater attenuation properties against pro-inflammatory cyclooxygenase-2 and 5-lipoxygenase (IC_{50} 0.98–1.34 mg mL^{-1}, $P < 0.05$) compared to those derived from other species (IC_{50} 1.99–5.02 mg mL^{-1}). The nuclear magnetic resonance-guided dereplication of organic extracts of the studied seaweed species recognized the co-linearity between the bioactive potential and downfield electronegative functionalities. These results recognized the significance of the organic extracts of *G. salicornia* and *P. tetrastromatica* to isolate compounds for functional food applications against oxidative stress and induced diseases, such as diabetes, hypertension, and inflammation.

Antioxidative 2H-chromenyls from *Babylonidae* gastropod mollusc,*Babylonia* spirata as prospective bioactive agents

Oxygenated heterocycles are emerging as valuable pharmacophores involved in the prophylaxis and treatment of several diseases elicited by the reactive oxygen species. Chromatographic fractionation of the organic extract of the gastropod mollusc *B. spirata* (family Babylonidae) yielded two unprecedented 2*H*-chromenyl derivatives characterized as 2-(butyryloxy)-5-hydroxy-hexahydro-2*H*-chromene-3-methyl carboxylate (1) and (3-hydroxy-hexahydro-2*H*-chromen-2-yl)methyl pentanoate (2). The chromenyl derivative (1) registered significantly greater attenuation potential against pro-inflammatory 5-lipoxygenase (IC_{50} ~ 2.02 mM) than those exhibited by the compound (2) (IC_{50} 2.76 mM). Inhibitory potential of chromenyl derivative (1) towards α-glucosidase (IC_{50} 1.18 mM) and α-amylase (IC_{50} 0.92 mM) were greater than those displayed by 2 (IC_{50} 1.16-1.56 mM). The chromenyl derivative bearing 2H-chromene-3-methyl carboxylate framework might constitute a prospective biogenic constituent in pharmaceutical applications.

Oxygenated elansolid type of polyketide spanned macrolides from a marine heterotrophic *Bacillus* as prospective antimicrobial agents

Three homologous oxygenated elansolid-type ofpolyketide spanned macrolides were isolated from a heterotrophic marine bacterium, *Bacillus amyloliquefaciens* MTCC 12716 associated with an intertidal red alga, *Hypnea valentiae*. Exhaustive spectroscopic studies unveiled the compounds to possess isobenzofuranyl benzoate and 1*H*-furopyrano[2,3-c] oxacyclononadecine-6-carboxylate moieties. The studied compounds displayed broad-spectrum bactericidal activity against methicillin-resistant *S. aureus* (MRSA), vancomycin-resistant *E. faecalis* (VRE), drug-resistant strains of *P. aeruginosa* and *K. pneumonia* with MIC ≤ 1.0 μg/mL, whereas the standard antibiotics ampicillin and chloramphenicol were active only at concentrations ≥ 6.25 mg/mL. The plausible mechanism of elansolid-type macrolides biosynthesis by *trans*-AT polyketide synthases through the *pks* starter unit para-hydroxybenzoic acid was hypothesized. The higher electronic values along with optimum lipophilic parameters supported the potential anti-infective properties of the studied macrolides.

Development of small molecular weight angiotensin-II converting enzyme inhibitor from marine organisms

Characterization of bioactive chromen, oxepin, and dihydrobenzofurans from the marine microalga *Chlorella salina* was carried out.: The study demonstrated marine microalgae as valuable natural sources of bioactive compounds with antihypertensive activities. The organic fractions of *C. salina* exhibited potential antioxidant activities (IC_{50} 0.45 mg/mL). The organic extract of *C. salina* was sequentially fractionated by column chromatography to yield substituted dihydro-2H-chromen-6-yl)butanoate (1), hexahydro-1H-isochromanone (2), substituted oxepin-6-yl-(4a-methylpent-3a-enoate) (3), and a dihydrobenzofuran derivative (4). In an attempt to predict the biological properties by chemiinformatic tools and quantitative structure-activity relationship analyses, the antioxidative and anti-hypertensive properties of the studied compounds from *C. salina* were corroborated with their structural descriptors.

Broodstock and Seed Production

Seed production of Cobia, Silver Pompano and Orange Spotted Grouper was continued and consistent survival rate of 9.0% for Cobia; 23.5% for Silver Pompano and 12% for Orange Spotted Grouper achieved in the larval rearing phase.

1.

Breeding and seed production of Cobia, *Rachycentron canadum* at Mandapam

During 2019-20, four successful spawning inductions of cobia were carried out and fertile eggs were obtained. Cobia eggs per spawning ranged from 0.5 to 1.7 millions and the mean percentage of fertilization and hatching were 75.0 and 82.0, respectively. Water quality parameters were maintained within the optimal range through indigenously designed filtration systems. The brood stock fishes were fed with good quality fresh squid and crab. A total of 25,100 cobia fingerlings were produced with a mean survival rate of 9.0 per cent. A total of 22,375 fingerlings were supplied to farmers and research institutions for farming, field demonstrations and brood stock development. About 2725 fingerlings are being reared for research purpose and for supplying to farmers to carry out demonstrations on sea cage farming at Mandapam centre.

Breeding and seed production of Silver Pompano, *Trachinotus blochii* at Mandapam

Silver Pompano *Trachinotus blochii* brood stock (6 sets) were maintained in 10 ton capacity FRP tanks fitted with photo thermal and water quality management systems. They were fed with good quality fresh squid and crab meat *ad libitum* every day along with vitamin and mineral premix. Periodic cannulation was carried out in the female fishes to ascertain the gonadal maturity. A total of 44 successful spawning inductions were carried out during 2019-20 and fertilized eggs were obtained. The total number of eggs per spawning ranged from 0.2 to 5.1 lakhs. The mean fertilization rate was 64.5 per cent and the mean hatching rate was 77.5 per cent. The average survival rate of silver pompano larvae in larval rearing was 23.5%. A total of 2,63,575 fingerlings were produced and 2,36,960 fingerlings were supplied to farmers, fishermen and research institutions in Karnataka, Kerala, Tamil Nadu, Puducherry, Andhra Pradesh and West Bengal for farming and field demonstrations. About 26,600 fingerlings were used for conducting research experiments at CMFRI centers.

Brood stock development of cobia and silver pompano at sea cages in Mandapam

Sub-adults of hatchery produced cobia (141 Nos.) and silver pompano (160 Nos.) are being reared for brood stock development in HDPE sea cages of the centre. The body weight of sub-adult cobia and silver pompano ranged from 4.5 to 7.8 kg and 1.1 to 1.8 kg, respectively. All the sub-adults of cobia and silver pompano are fed with high quality low value fishes, squid and crab meat @ 3 to 5% and 5 to 8% respectively, of their body weight. Periodic monitoring of growth and health parameters are being carried out.

Breeding and seed production of Orange spotted grouper at Visakhapatnam

Orange spotted grouper larval (metamorphosed) production has been consistently achieved with a survival rate of 12%. The size of the metamorphosed larvae after 40 days of rearing in the hatchery ranged from 2.5 to 2.9 cm in length and 0.25 to 0.30 g in weight. A total of more than 50,000 seeds

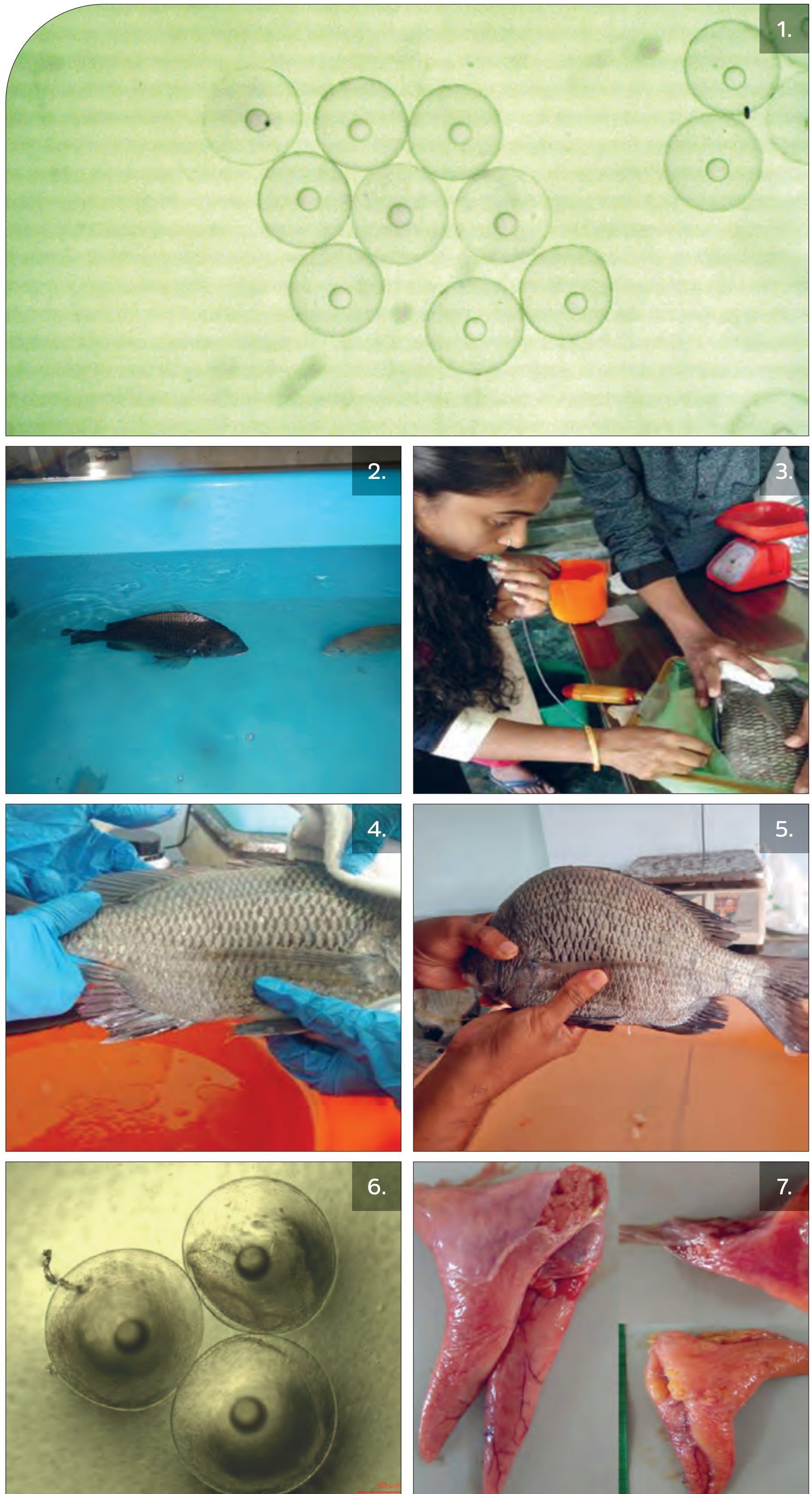
1. Packing of seeds for transportation
2. Handing over of silver pompano larvae to TNJFU hatchery
3. Distribution of silver pompano larvae to M/s. MSR Hatchery, Kakinada

were produced during the year. Seeds were used for pond and cage culture demonstration purposes. To overcome the temperature drop during winter, the larval rearing facility of Orange spotted grouper was converted to poly/ greenhouse roofing. This resulted in an increase of $3-4^{0}C$ which eventually increased the larval survival by 1% and larval growth by 5%.

Broodstock development of other prioritized species for mariculture in various centres

At Karwar Centre, broodstock development of 5 marine finfish species viz, *Acanthopagrus berda, A. latus, Lutjanus argentimaculatus, L johnii and Siganus vermiculatus* were carried out in five 6m dia GI cages. All the fishes were fed with broodstock feed (squid, crab, clam and oyster etc) @ 10% biomass and cannulated at regular intervals for assesing the gonadal maturation. Breeding trials of *Acanthopagrus latus* were carried out by collecting fishes from the Kali estuary, Karwar, India from September 2019 to January 2020. Majority of the fishes collected were in 20 -30 cm length class which comprised females with maturing oocytes and oozing males. Regular ovarian biopsy and microscopic observation indicated the progressive gonadal development. Hormonal inducement of a mature male and female pair using ovaprim @ 0.5 ml / kg for female and 0.25 ml / kg for male led to the spawning of the fish after 48 hours.

At Calicut centre, broodstock development and induced breeding trials in *Acanthopagrus berda* is being carried out in 5 ton capacity tanks fitted with recirculatory aquaculture system (RAS). The individual dose of WOVA FH and combination of WOVA -FH and LHRH are found effective in inducing spawning in female *A. berda*. Injection of high dose of WOVA-FH, Ovatide and LHRH made the possibility of hand stripping of ova from the females after 48 hours of injection. The hand stripped ova and milt were mixed thoroughly using a feather for 2 minutes and were maintained at different salinities (15, 25 and 35 ppt) and kept undisturbed for 2 hours. Fertilization was observed in all the salinity treatments. Procedure for cannulation, anesthesia and stripping were also standardized by conducting several breeding trials. These results indicate the possibility for successful induced breeding of these species in captivity. The standardization of doses of inducing agent, incubation time, conditioning



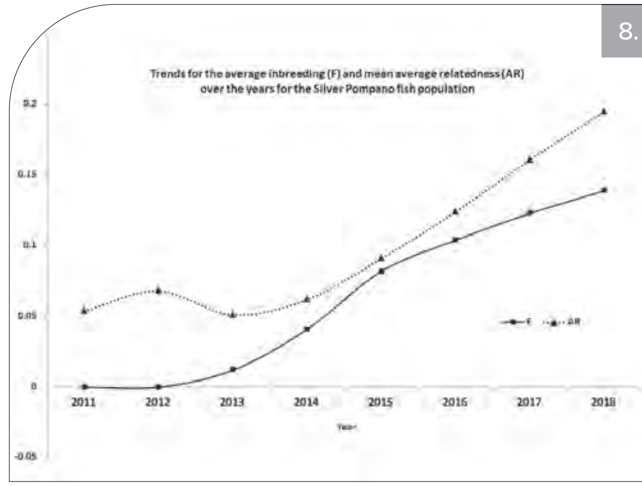
of the brooders, etc is necessary and the work is under progress. Salinity tolerance was studied in the fingerlings of *A. berda.* The fingerlings could tolerate a wide range of salinities from 0-40 ppt. Silver pompano fingerlings (6800 Nos.) procured from Mandapam regional centre were also reared to cage stockable size and supplied to the farmers.

At Chennai centre, the broodstock of Indian Halibut *Psettodes erumei* is being maintained in the hatchery and studies on their behaviour and adaptation are in progress.

At Veraval centre, the silver pompano *Trachinotus blochii* fingerlings were transported from Mandapam RC hatchery to Veraval by train. The travel lasted for 72 hours and a survival of 92.6% was achieved. This has demonstrated the sturdiness and extensive tolerance of transportation stress by the silver pompano fingerlings. At Tuticorin research centre, assessment of survival, growth and RNA/DNA (R/D) ratio of snubnose pompano larvae (2 to 11 dph) fed with different live feeds was carried out. Larvae fed with *Parvocalanus crassirostris* nauplii (5 nos / ml) and algal enriched rotifer (5 nos / ml) showed higher survival percentage (14%) and higher (R/D)

1. Spawned eggs of *Acanthopagrus latus*
2. *Acanthopagrus berda* brooders
3. Cannulation of female *Acanthopagrus berda*
4. Hand stripping of female *A. berda*
5. Milt oozing male of *A.berda*
6. Eggs of *A. berda*
7. Ripe ovaries in *Psettodes erumei*
8. Trend of the average inbreeding (F) and the mean average relatedness (AR) over the years for the Silver Pompano population

8.



ratio in comparison to *Acartia southwelli* nauplii and enriched rotifers. At Kochi, brood stock of *L. argentimaculatus* are being reared in the cages at North Paravoor. Tagging was done for the brood stock and periodic cannulations are being carried out.

Genetic management of breeding populations of the silver pompano at Mandapam

The breeding data of cobia and silver pompano populations are being maintained at Mandapam from 2010 to till date. Data on pedigree information (n=413) of silver pompano for 8 years (2011-2018) were analyzed. Molecular marker (microsatellites) based software program FAP (Family Assignment Program, version 3.6) was used for parentage assignment. Pedigree analysis and estimation of population genetic parameters based on the gene origin probabilities were performed using the software program ENDOG (version 4.8). The study has implicit reference population against which the parameters were computed. Generation interval, coefficients of inbreeding and relatedness, individual increase in inbreeding (rate of inbreeding), realized effective population size, effective numbers of founders, ancestors, founder genomes and non-founder genomes and the loss of genetic variability caused by genetic bottleneck and genetic drift were computed. The realized effective population size was 10.53 which is very small and with the increasing trend of inbreeding, the situation has been assessed to be critical. The analysis revealed the evidences on loss of genetic variability with a critical effective population size and resulting in disequilibrium among the founder contributions in the population. The parameters computed from pedigree are needed to assess the quantitative genetic architecture of traits, status of inbreeding and to genetically manage the breeding population. The summary statistics of the pedigree analysis of the captive-bred breeding population of the silver pompano is given.

The genetic variability in the broodstock populations of cobia and silver pompano is being monitored for producing high quality seeds to farmers and other stakeholders.

The summary statistics of the pedigree analysis of the captive-bred breeding population of the silver pompano

Parameters	Reference Population	Whole Population
Total number of brood fishes	57	413
Total number of founders	30	92
Number of ancestors contributed	24	38
Effective number of founders (fe)	16	29
Effective number of ancestors (fa)	14	24
Founder genome equivalents (fg)	7.23	9.71
Effect. No. of non-founders (nfe)	19.25	12.12
Ancestors explain 75% variation	11	21
Ancestors explain 50% variation	7	13
Mean Inbreeding (F)	0.091 ± 0.033	0.063 ± 0.021
Average Relatedness (AR)	0.120 ± 0.067	0.101 ± 0.024
Rate of inbreeding (ΔFi)	0.048 ± 0.019	0.035 ± 0.011
Equivalent generations (t)	3.29 ± 0.27	1.68 ± 0.12
Realized effective size (ΔFi based)	10.53 ± 2.66	--
Realized effective size (Cij based)	11.42 ± 2.76	--


1.

Broodstock development, breeding and seed production of sand lobster at Chennai

At Kovalam field centre, four trials of sand lobster larval rearing carried out during May to September 2019 gave close to 1% settlement stages. Three trials in January to March 2020 progressed to the final settlements but the survival was poorer with two time feeding schedule. Photo feeding tube system in Sand lobster larvae improved the feeding and conversion efficiency.

Seed production and sea ranching of Green Tiger Shrimp (*Penaeus semisulcatus*) at Mandapam

The mariculture division of the Mandapam regional centre of CMFRI is regularly carrying out sea ranching of hatchery produced seeds of green tiger shrimp, *Penaeus semisulcatus* at Gulf of Mannar and Palk Bay to replenish the natural stock and to enhance the shrimp productivity. This will be helpful for conservation and in maintaining a sustainable shrimp stock in the wild and will also improve the livelihood of the fishermen in this region. During 2019-20, a total of about 3.6 million shrimp seeds of PL 15-35 size produced in the shell fish hatchery were sea ranched in Gulf of Mannar and Palk Bay.

The seeds were produced using wild collected brooders obtained from the shrimp trawlers operated in Gulf of Mannar and Palk Bay. After spawning, nauplii were transferred to 5 ton capacity larval rearing tanks. Larvae from protozoea I to Mysis III were fed with *Chaetoceros* spp. Post larvae 1

Details of sea ranching of Penaeus semisulcatus during the year 2019---2020

Date	Quantity	Location	In the presence of
04.05.2019	10.0 Lakhs (PL20-35)	Thonithurai, Palk Bay	Dr. K. K. Joshi, Head, Marine Biodiversity Division, CMFRI, Kochi released shrimp seeds in the presence of Dr. R. Jayakumar, Scientist-in-Charge, scientists and leaders of fishermen associations.
03.08.2019	7.5 Lakhs (PL 15)	Thonithurai, Palk Bay	Shri. K. Muralidharan, Member, Institute Management Committee ICAR-CMFRI, Dr. G. Tamilmani, Senior Scientist, Officials of State Fisheries Department, Scientists and staff of Mandapam Regional Centre of ICAR-CMFRI, Leaders of Fishermen associations and local fishermen released shrimp seeds
04.09.2019	2.75 Lakhs (PL 30)	Thonithurai, Palk Bay	Dr. R. Jayakumar, Scientist-in-Charge, Mariculture scientists and staff of Mandapam CMFRI released shrimp seeds.
08.12.2019	12.00 Lakhs (PL-15)	Thonithurai, Palk Bay	The Director, CMFRI, Kochi Dr. A. Gopalakrishnan, Members of Institute Management Committee, Dr. K. A. Saira Banu, Former Commissioner of Fisheries, Govt. of Kerala, Dr. P Muralidharan, Head, KVK, CPCRI, Kayamkulam, Kerala, Shri. K. Muraleedharan & Shri. K. Raghunadhan, Administrative Officer and Dr. R. Jayakumar, Scientist-in-Charge, Smt. V. Prabhavathi, DDF (Regional), Govt. of TN, Shri. J. L. Ajith Stalin, ADF, Mandapam, Scientists and staff of Mandapam along with the leaders of fishermen associations and local fishermen released shrimp seeds
21.12.2019	5.00 Lakhs (PL-25)	Munaikadu, Palk Bay	Member of Institute Management Committee ICAR-CMFRI Shri. K. Muraleedharan, Dr. R. Jayakumar, Scientist-in-Charge, Scientists and staff of Mandapam Regional Centre of ICAR-CMFRI, Leaders of Fishermen associations released the shrimp seeds


2.


3.

4.

1. Necrotic blackening in the phyllosoma 4 leading to morbidity
2. Sea ranching programme of green tiger shrimp
3. Sea ranching on 04.05.2019
4. Sea ranching on 21.12.2019

to post larvae 20 were fed with combination of rotifer, *Artemia* nauplii and encapsulated larval feeds. All the larval stages were observed under microscope for analyzing health and feeding status. Water quality parameters were maintained within the optimum range. Water exchange was carried out from 20 to 40% on daily basis. Larvae were reared up to the stages between PL-15 and PL-40 and were used for sea ranching programme.

Impact study on sea ranching of Green tiger Shrimp in comparison with shrimp landings data collected from landing centres at Mandapam

The data on *P. semisulcatus* shrimp landings were collected from different landing centres (Rameswaram, Pamban, Mandapam and Soliyakudi) on the first day of fishing after the fishing ban period. The average catch per boat reported was 900, 800, 600 and 500 kg, respectively and the total landings were reported as 800, 48, 450 and 55 metric tonnes from the above 4 landing centres, respectively. The shrimp landing data of previous three years after the fishing ban period were compared with the data of current year. The study revealed that there is a significant increase in shrimp landings as a result of the sea ranching programme carried out by CMFRI.

Genetic stock identification on the impact of sea ranching of Green Tiger Shrimp at Mandapam

The Genetic stock Identification (GSI) of Green Tiger Shrimp *Penaeus semisulcatus* is being carried to evaluate the impact of sea ranching on shrimp landings using polymorphic microsatellite molecular markers. The pleopod samples from broodstock, post larvae and shrimp landings along the Gulf of Mannar and Palk Bay were regularly collected and

stored in ethanol for DNA isolation. Eight Microsatellite markers reported by Jahromi et al. 2011 for *P. semisulcatus* were procured for this study and checked for PCR amplification.

Broodstock development, breeding and seed production of marine ornamental fishes

At Kochi, broodstock development and pair formation for breeding between *Amphiprion percula* (female) and *A.ocellaris* (male) were achieved through GnRH hormonal administration. Consistent breeding of the pairs successfully achieved and the fishes laid 900 to 1200 eggs per spawning at an interval of 10 to 12 days and a total of 25 spawning were obtained. Broodstock development, breeding and larval rearing of *A.percula*, *A. frenatus*, *A. sebae*, *A.clarkii* and *Premnas biaculeatus* were carried out. Sale of hatchery produced seeds were carried out through ATIC at Kochi. Breeding and seed production of black *Ocellaris* was successfully completed. One pair of Domino clown broodstock was also developed under captivity. Brood stock development of *A. akallopisos* were carried out under captivity. The three pairs of *A.akallopisos* were developed and breeding was successful and the pairs laid 500 to 800 eggs/pair/month. Consistent breeding obtained every 12 to 15 days interval. The larvae were daily fed with different live feeds. The larval rearing was standardized. Broodstock development of *Ptereleotris evides* was carried out. The broodstocks reached 10 to 12 cm size. Selection of broodstocks from the hatchery produced juveniles of clown fishes (mis band and intermittent band) were selected for selective

1. Samples collected for GSI studies from different landing Centre's
2. Crossbred offspring of Black ocellaris and Percula clowns produced at Mandapam
3. Three spotted damsel fingerlings produced at Mandapam

Revenue generation through the sale of seeds and live feed at Mandapam

S.No.	Source of revenue	Amount (₹)
1.	Sale of Cobia seeds	5,42,250
2.	Sale of Silver Pompano seeds	5,72,300
3.	Sale of Marine Ornamental Fish seeds	3,47,255
4.	Sale of live feed	1,220
Total		14,63,025

breeding of clownfishes. The fishes with variation in banding pattern were chosen and the work is in progress.

At Mandapam, broodstock development, breeding and seed production of marine ornamental fishes (Designer clown fish varieties viz., Platinum, Snow flake and Picasso, Percula clown, Tomato clown, Skunk clown, Maroon clown and Damsel fishes) were carried out as a programme of revenue generation through the technology developed by CMFRI. A total revenue of ₹.3,47,255/- was generated through the sale of marine ornamental fish seeds produced at Mandapam. From this ₹.72,555/- was deposited in ICAR account and ₹.2,74,700/- was remitted under the ICAR Mega Seed Project's revolving fund account.

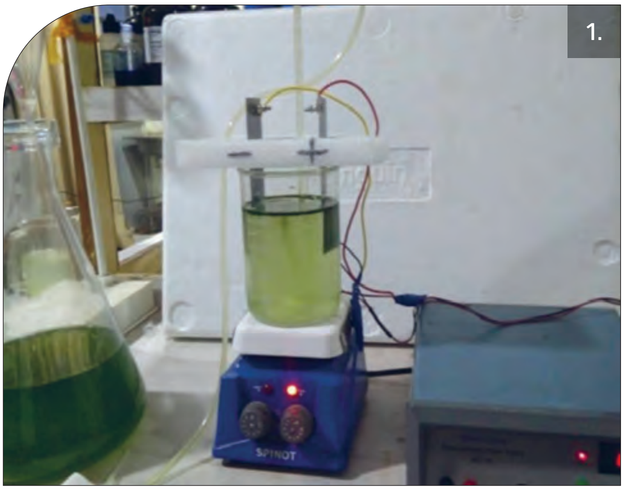
At Visakhapatnam centre, revenue of ₹ 8.0 lakhs was generated through the sale of algal species and zooplanktons (rotifers and copepods) to shrimp hatcheries located in the East Coast.

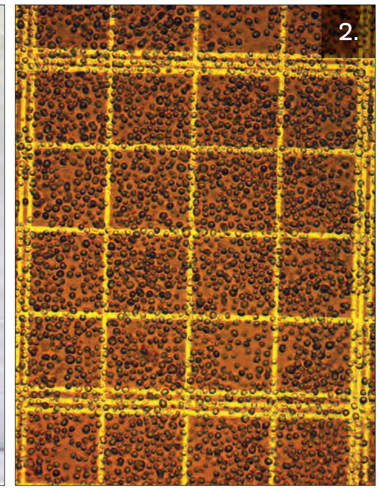
Production of live feed

At Vizhinjam centre, stock of 8 popular and important species of copepods Calanoid copepods *Acartia southwelli*, *Parvocalanus crassirostris, Bestiolina similis, Pseudodiaptomus serricaudatus* and *Temora turbinata,* Cyclopoid copepods *Oithona brevicornis, Dioithona oculata* and Harpacticoid copepod *Euterpina acutifrons* are being maintained and regularly distributing the stock cultures to various users. Suitability of 10 species of common microalgae and their combinations were also evaluated for feeding *Parvocalanus crassirostris, Bestiolina similis* and *Oithona brevicornis.*

At Mandapam centre, the pure culture of micro algae and diatoms are being maintained (*Nannochloropsis occulata, N. salina, Isochrysis galbana, Tetraselmis species*, marine chlorella, *Dunaliella* sp., *Chaetoceros* sp., *Skeletonema* sp., *Thalassiosira sp.,* etc.) for supporting the larviculture activities at the centre as well as for supplying to private hatcheries as per the demand. The species which are mass produced for supplying to larviculture operations include *N. occulata, N salina, I galbana and Chaetoceros sp.* The zooplanktons which are being mass produced include the species of rotifers *viz., Brachionus plicatilis* & *Brachionus rotundiformis* and the species of copepods *viz., Acartia sp.* and *Parvocalanus sp.* for the purpose of seed production.

At Visakhapatnam centre, mass production of copepods is being carried out regularly. Stocking density of adult copepods (*Parvocalanus*) were standardised in the mass culture as 1 adult per ml and harvested 55 million of copepod naupli in 5 tonne water (11nos/ml). Effect of different metals on electroflocculation of *Nannochloropsis oculata* was studied. Metals like Zn, Al, Cu, Brass and Fe have been used for the electroflocculation study to





prepare the algal concentrates. The individual metals were used as both cathode and anode. Exponential phase culture of *Nannochloropsis* was used for preparation of concentrates. The electrodes were connected to a DC power supply and the voltage was adjusted to 20, 40, 60, 80 and 100V and current was kept constant at 90mA. Aluminium electrode performed better with flocculation efficiency of 92% at 60V for 30 min.

At Karwar centre, stock and carbouy cultures of marine microalgae, *Nannochloropsis salina, Isochrysis galbana, Chaetoceros calcitrans, Tetraselmis chuii* are maintained for feeding copepods and rotifer. Copepods, *Parvocalanus crassirostris, Acartia tonsa, Apocyclopsis cmfri* are being cultured using *N. salina and I. galbana*. Rotifers, *Brachionus rotundiformis, B. plicatilis, Colurella* spp. are also cultured in the hatchery for larval rearing. At Calicut centre, stock cultures of 8 microalgal species like *Nannochloropsis oculata*, *Nannochloropsis salina, Isochrysis galbana, Chaetoceros calcitrans, Dicrateria gilva, Dunaliella salina, Fresh water chlorella* and *Marine chlorella,* two species of rotifers viz., *Brachionus plicatilis & Brachionus rotundiformis* and two species of copepods viz., *Acartia sp* and *Parvocalanus sp.* are being maintained.

Health management of fish broodstock at Mandapam

Immunization of cobia against Vibriosis

Mass immunization with a multivalent vaccine (0.1ml dose through intra-peritoneal route) was carried out in cobia (500 fingerlings) against vibriosis before stocking in the sea cages. The

1. Flocculated *Nannochloropsis* cells as a layer on the top
2. Flocculated *Nannochloropsis oculata* concentrate, Nanncon
3. Cobia fingerlings immunized before stocking
4. Immunizing the fingerlings through vaccinator
5. Immunization of cobia sub-adults
6. Immunization of cobia brooders

multivalent vaccine comprised of *V.alginolyticus, V.parahaemolyticus and V.harveyi* whole cell inactivated bacterial strains. The immunization was carried out with an initial dose in April 2019 followed by a booster dose in May 2019. The booster dose was administered after 28th day post vaccination (DPV). Serum was collected on 7th, 14th, 21st, 35th, 42nd and 63rd DPV and kept in -20°C for further antibody titre evaluation. The seasonal occurrence of vibriosis infection was comparatively lesser or nil during the months of August and September 2019. The OD values of antibody to the multivalent vaccine differed significantly ($P<0.05$) in the laboratory testing as well as in the field trials. There was a significant ($P<0.05$) increase in the OD values of antibodies from 7th to 21st DPV and dropped significantly ($P<0.05$) at 28th DPV. Hence, it was decided to give one booster dose on 28th DPV. The 35th day OD value was higher than 21st and 28th day, which indicates that the serum antibody levels were increasing after the booster dose of vaccine and immunity levels were extended further 35 days.

Analysis of the mass mortality of brood fishes of cobia in sea cages

A total of 49 brood fishes of cobia (35 males and 14 females) were maintained in sea cages for breeding and seed production. On 10th September 2019, the deep green bloom started along the coast of Gulf of Mannar stretching from Kunthukkal to Vedhalai (about 10 kms) and algal crashing started on 11th and 12th September, 2019 which, resulted in mass mortality of about 20 fish groups mostly associated with coral reefs all along the stretch. The icthyo-diversity affected during the bloom period have been identified and quantified. On 12th September, 2019, fishes such as Rabbit fish, Parrot fish, Grouper, Snapper, Breams, Mullet, Moray eels, Silver biddies, Carangids, Lizard fishes, Silver whiting, Surgeon fish, other coral reef associated fishes and marine ornamental fishes were found dead or moribund due to hypoxic condition and increased ammonia leaching from the dead and decayed dinoflagellate. The microscopic examination confirmed that the species was a dinoflagellate, *Noctiluca scintillans* and this bloom was the cause of fish mortality due to anoxic conditions and ammoniacal water prevailed in the affected area. The size of the individual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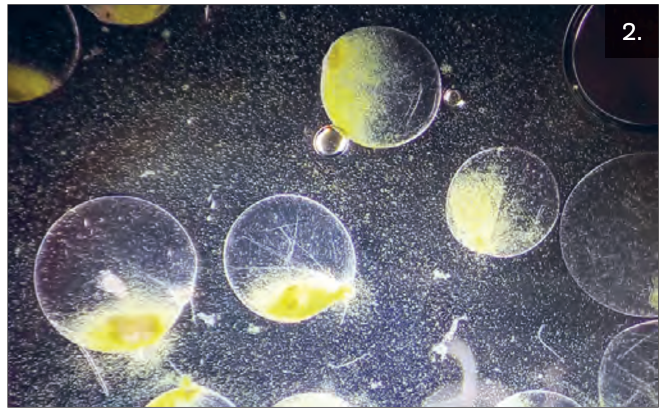
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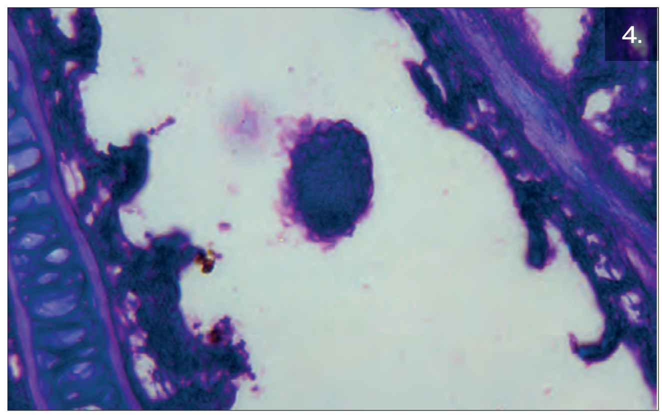
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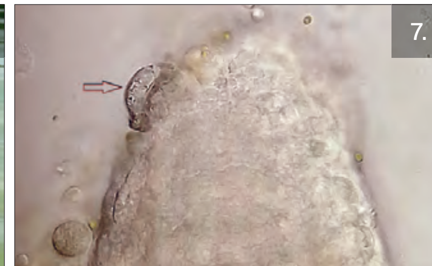
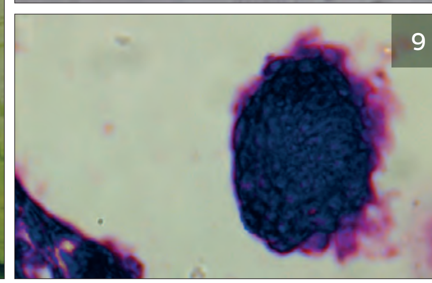
cells ranged between 400 to 900 micron and the cell density measured was about 5.6 x 10^3 to 8.0 x 10^3 per litre. A detailed study on the algal bloom was carried out and the physico-chemical parameters were documented.

On noticing the bloom, efforts were taken on a war footing manner to save as many brood fishes as possible. The brood fishes were brought into the indoor recirculation facility of the centre. A total of 17 brood fishes of cobia (11 males and 6 females) could be saved. A total of 32 cobia brooders (24 males and 8 females) succumbed to died in sea cages due to choking of the gills and hypoxia. Following this, dead fishes were examined *post mortem* and tissue samples were taken for further examination. Efforts are being taken to collect sub-adults/brooders of cobia from the wild to overcome the present bottleneck.

Parasitic infestation in cobia fingerlings reared in hatchery

Trichodiniasis is one of the highly significant ectoparasitic diseases affecting aquaculture, resulting in growth retardation and immunity interference leading to chronic infections and mortality. Trichodiniasis infestation was noticed in cobia fingerlings at the marine hatchery in Mandapam. As per the FDA-approved recommendations, formalin (200-250 ppm) bath for 60 minutes thrice daily with 3 hours interval was practiced in the hatchery to control the infestation. Further, the fingerlings





1. Occurrence of deep green algal bloom at Kunthukkal coastal water on 11th September, 2019
2. Sample of Algal bloom on 17th September, 2019
3. Mortality of cobia broodstock in cages
4. Cobia brood stock having algal mass in gills
5. Microscopic view of *N. scintillans* with flagella
6. Occurrence green algal patches of bloom at Marakayar pattinam coastal water on 17th September, 2019
7. Wet smear: Cobia gills affected by the ciliates *Trichodina* species
8. Wet smear: Ciliates of *Trichodina* species
9. Histology of Gill: Gill secondary lamellar necrosis by *Trichodina* species H&Ex400X

were treated with Formaldehyde, Gluteraldehyde and Benzalkonium chloride (Bioline Plus, SDC Agro Vet, India Pvt. Ltd) @ 20ml/tonne water for 30-40 minutes followed by complete water exchange to avoid over exposure and any adverse effects of chemicals. Additionally, the fingerlings were supplemented with immunostimulants added in the feed for the next 3 weeks for improving the immunity.

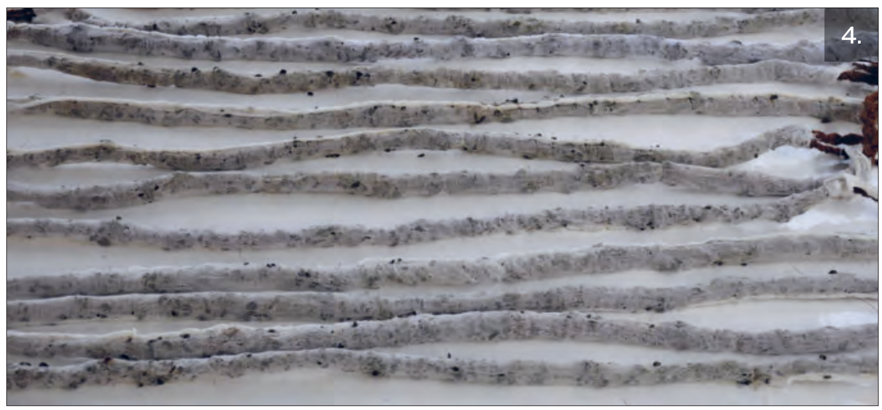
Mussel seed production

Research Project MFD/MOL/Sub/17

Micro-nursery system established has started producing bivalve seed at Vizhinjam Research Centre of CMFRI (VRC). Micro-nursery system consists of one downwelling and one upwelling subsystem and each with separate reservoir tanks and pumps for providing water circulation. In the down-welling system eyed stage larvae of mussel, oyster or clam can be stocked at high density for settlement and further growth. When the settled spat reaches 4 mm size, it can be transferred to the upwelling system for further rearing. Three trials were conducted in different stocking densities of green mussel eyespot larvae (2.5, 3.0, 3.5 and 4.0 lakh larvae /well. Wells were stocked with 3.5 lakh had good survival and growth and utilized the capacity of the well efficiently.

Plan and the design for the first bivalve hatchery in India were finalized with the technical guidance of Vizhinjam CMFRI, and the MOU signed with Maharashtra Fisheries Department. A Draft for the bivalve hatchery was also prepared and



1. Bivalve micro-nursery at Vizhinjam Regional Centre of CMFRI
2. Spat settled in downweller
3. Mussel seed
4. Seeded ropes prepared for sale

submitted to the Kerala State Fisheries Department as per their request.

VRC produced Asian green mussel, *Perna viridis* seeds from its research scale bivalve hatchery and seeded ropes were sold to the farmers through the Kerala State Fisheries Department. Each seeded rope was sold at the rate ₹.350 to the farmers from Trivandrum, Kollam and Alleppey district.

NFDB-CMFRI Brood banks becomes functional

The broodbanks established at Mandapam and Vizhinjam RC of CMFRI started functioning this year. More than 100 pairs of pompano and 214 cobia has been developed as broodstock under two NFDB sponsored project. The broodbanks of Cobia and Pompano will supply fertilized eggs/ yolk sac larvae to various hatcheries identified by NFDB for rearing and production of fish seeds.

Growout Technologies

Research Project No: MDN/CGE/19

RAS prepared for nursery phase

Refinement and demonstration of cage farming technology for high valve marine finfishes and technical guidance to the fisher-folk for carrying out the cage farming in a profitable manner is being extend through various Centres ofCMFRI.

Experiments on antifouling coating on cages

In sea cage farming, fouling is a major problem and it causes several maintenance and operational difficulties that affect not only the integrity of nets and cage structures but also the growth performance and health status of fish. Fouling in sea cages can result in severe economic loss to the farmers through net occlusion, weight addition, disease risk, etc.

Antifouling paint is a specialized coating, normally containing a formulation of water-soluble bioactive ingredients and organotin compounds applied to the cage frames, slows the growth of barnacles, algae and marine organisms that attach to the cage frame. A commercially available antifouling coating, TORPEDO, a vinyl antifouling paint with cuprous oxide and organic biocides as active ingredients for long term resistance to weed, shell and animal fouling was used to top coat the HDPE frame of the sea cages. Initially, three pieces of HDPE pipes were coated with the antifouling paint and tied to hang along the cage frames. The cage frames were considered as control and the coated pieces of HDPE pipes were periodically observed for assessing the fouling. It was found that the biofouling was significantly lesser in the HDPE pipes coated with antifouling paints. Further repetitive trials are needed to ascertain the effects of antifouling coating on the cage frames as well as on the fishes reared in the cages.

Farming of Spiny lobsters in sea cages

Demonstration of capture based cage farming of spiny lobsters was conducted with the participation of two progressive fish farmers. Juveniles of spiny lobsters *Panulirus homarus* and *Panulirus ornatus* with an average size of 85.5 grams were procured from Cuddalore and Kanyakumari Districts of Tamil Nadu and stocked in sea cages installed in two locations (Mandapam and Pamban). Two cages of 6 m diameter, 3.5 m net depth and mesh size of 30/40 mm for inner and outer nets were installed at both the locations. A total of 500 numbers of juveniles were stocked in each cage. Hide-outs were kept for controlling the cannibalism during moulting. Feeding was carried out with trash fish @ 10% of total biomass. Periodic sampling was

1. Sea cage with biofouling
2. Experimental cage tied with the antifouling coated HDPE pipes
3. Sampling of lobsters

carried out to evaluate the growth. The details of growth are given below.

The final survival at Mandapam and Pamban was 77.2 and 84.9 per cent, respectively. A final harvest of 118.0 kg and 143.7 kg were obtained from both the locations. The harvested lobsters fetched a farm gate price of ₹2000/kg.

Integrated Multi-trophic Aquaculture of Silver Pompano with Seaweed

Fingerlings of Silver pompano, *Trachinotus blochii* with a mean size of 68.89±10.05 mm in length and 6.41±2.61 g in weight were stocked in a 6 m diameter cage for sea cage farming along with seaweed rafts *Kappaphycus alvarezii* at Munaikadu village, Mandapam.

Culture Period	Mean Weight (g) of farmed spiny lobsters	
	Mandapam	Pamban
Stocking size	85.5	85.5
45 days	119.8	136.4
90 days	170.8	198.2
135 days	238.1	266.6
180 days	305.7	338.4

A total of 16 nos. of seaweed rafts @ 60 kg of seaweed per raft were integrated as the component of inorganic extractive with pompano cages by the next day of stocking. The feeding was carried out with low value fishes initially @ 8-10 % of total biomass which was later reduced to 5-8 per cent. The fishes were harvested after a culture period of 10 months with an average weight of 650 g. Harvested fishes fetched a farm gate price of ₹360/ Kg. A final harvest of 1.105 tonnes of fishes and 19.2 tonnes of fresh seaweed (from 5 cycles) were obtained during this demonstration.

Trial on Integrated Multi-Trophic Aquaculture (IMTA) by integrating cobia farming with seaweed *Gracilaria edulis* was attempted. One cycle of *Gracilaria edulis* farming was undertaken.

Effect of stocking density and feeding frequency on the growth performance of Orange spotted grouper

Effect of different stocking density and feeding frequency on growth and feed utilization in nursery rearing of orange spotted grouper was studied at Visakhapatnam. Advance fry stage

(2- 2.5g) of orange spotted grouper were stocked at three different stocking densities (300, 400 & 500/m^3) and reared for 45 days till the fingerling (15g) size for grow out systems. Water in the rearing tank was exchanged twice in a day and the water quality parameters were monitored once in a day. The observed result showed that, fishes reared in 300/m^3 reached 16.9 g in 45 days of experiment, and the fishes reared at 400 and 500 /m^3 attained the size of 14.78 and 11.7 respectively.

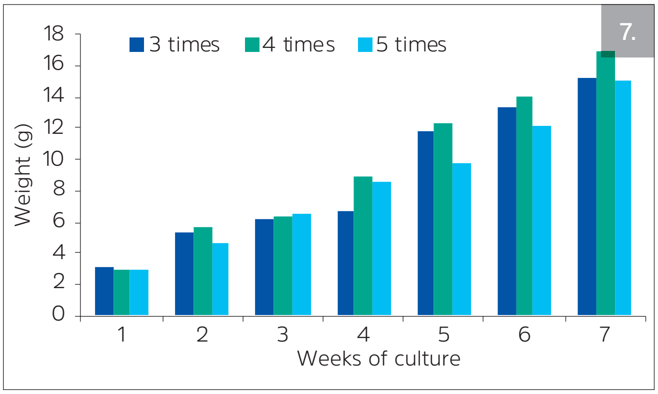
Study on different feeding frequencies such as 3, 4 and 5 times in a day showed that fingerlings fed for 4 times in a day showed better performance at stocking density of 300 & 400/m^3. Whereas the fish stocked at 500/m^3 showed better performance at 3 times per day.

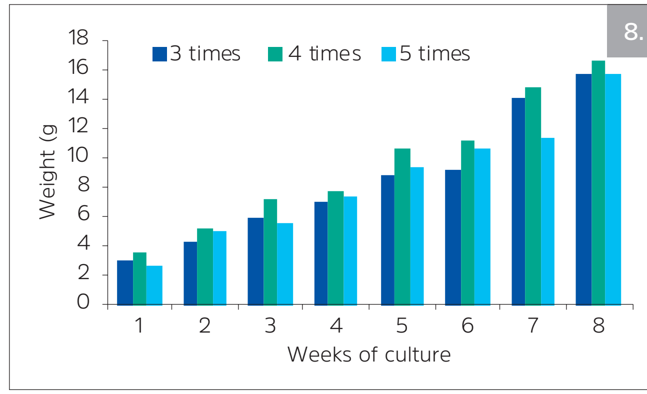
Nursery rearing of Indian Pompano in RAS

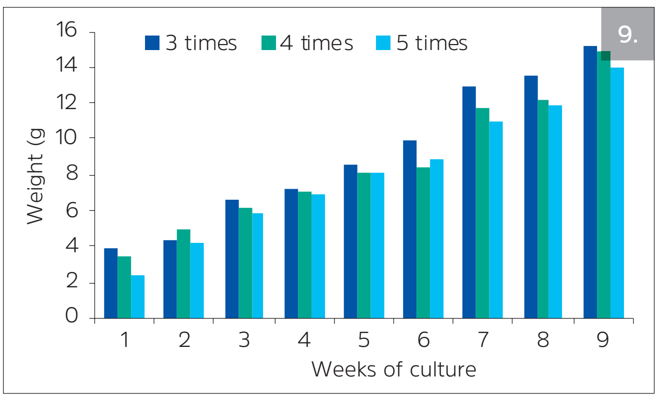
Rearing of early fry of Indian pompano was experimented in RAS system. The RAS system consists of 10 numbers of concrete cement tanks each with 10 tonne capacity. Hatchery produced Indian pompano fry (0.45g), were stocked in RAS @ 500/m^3, and all the stocked fry fed with pelleted feed of 45 % crude protein, four times in a day. Water in the culture tank was recirculated continuously, and water quality parameters were monitored. The growth study showed that the stocked early fry has reached a size of 0.45g to 8 g in a two-month period. The observation showed that, the fingerlings stocked @ 500/m^3 encountered frequent bacterial attack and oxygen depletion.

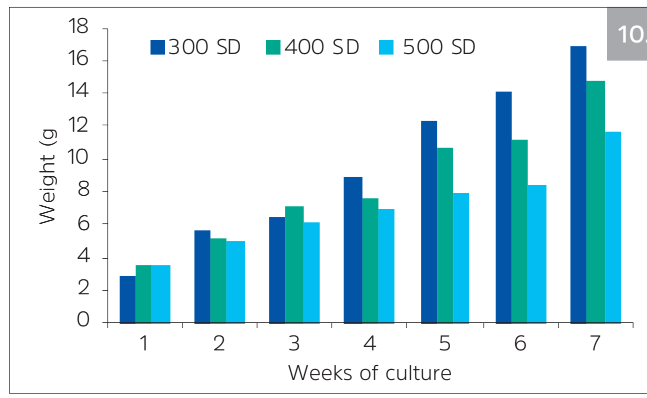
Nursery rearing of Indian Pompano cages

Nursery rearing of Indian pompano was performed at different stocking density in high saline backwater cages. Stocking density of 50, 100, 200/ m^3 were tested among which the fish fingerlings stocked at 50/m^3 showed higher growth performance in three months period.









1. Cage farming site
2. Harvested Pompano
3. View of the *Gracilaria edulis* seeded raft
4. Integration of *Gracilaria* raft with cobia farming cage
5. Seaweed raft ready for harvest
6. View of harvested rope
7. Growth of orange spotted grouper stocked at 300/ m^3 and fed at 3 different feeding frequency
8. Growth of orange spotted grouper stocked at 400/m^3 and fed at 3 different feeding frequency
9. Growth of orange spotted grouper stocked at 500/m^3 and fed at 3 different feeding frequency
10. Growth of orange spotted grouper in different stocking densities

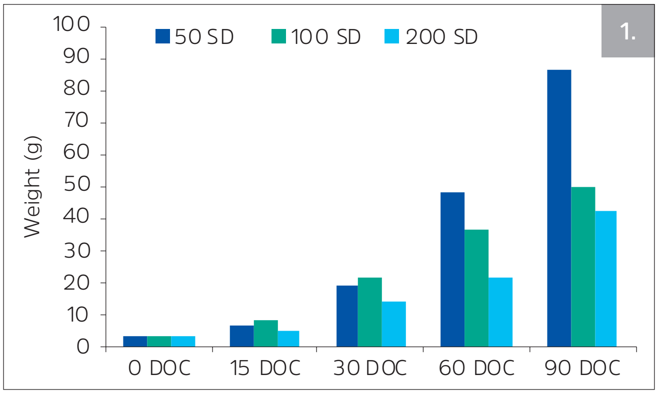
During the nursery period, fingerlings were fed 4 times in a day at 8-10% of their body weight.

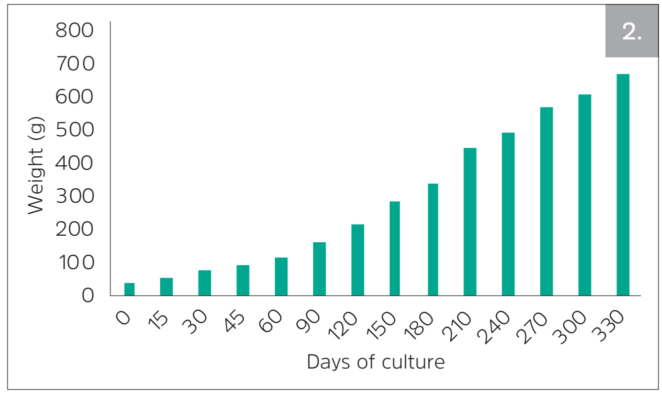
Culture of Orange spotted grouper

Suitability of Orange spotted grouper for pond farming was studied at Visakhapatnam centre. The fingerlings of orange spotted grouper of 40-50g in size were stocked in two ponds @ 3000/Acre. Seed were fed with pelleted feed of 3 mm size (Growel feeds Pvt. Ltd). Due to the demersal behaviour, the fishes did not respond properly for feeding, and hence tilapia brooders were released in to the culture ponds @ 2000 nos. /Acre. The tilapia fry produced from frequent spawning formed the feed for the groupers stocked in the pond. After reaching 400g, the fish also fed by the fresh chopped adult tilapia @3-4% of body weight, which showed good acceptance. Growth was monitored at every fortnight, and the orange spotted grouper cultured in two ponds has exhibited size variation. In the fishes harvested, 30-40% of the fishes in the both ponds have reached an average size of 1.5 kg.

Cage culture of Orange spotted grouper at different stocking densities in cages

Hatchery produced orange spotted grouper fingerlings (20g) were stocked in different stocking densities such as 10, 15, 20 and 25/ m^3 in HDPE open sea cages. The fishes were fed twice in a day with combination of high protein pellet feed and low value fishes (Tilapia). The growth of fishes stocked





in cages was regularly monitored for every 15 days. After 205 days of culture, fish has attained the size of 468g and 421g for 15 and 25/ m^3, respectively. The 75 days of culture trial for stocking densities of 10 and 20 has showed the growth of 122 and 117g, respectively. The farming trial for all different stocking densities is continuing.

Technology support for development of sea cage farming by fishers

The technical guidance to the fisher-folk for carrying out the cage farming in a profitable manner is being extended every year by the Mandapam Regional Centre of CMFRI on a continuous basis. Based on several successful demonstrations by the Mandapam Regional centre, the Department of Fisheries, Government of Tamil Nadu and the District administration of Ramanathapuram extended financial assistance to the fishermen SHG's under the State Balance Growth Fund (SBGF) and FIMSUL – II project. The fishermen themselves invested and the cages were fabricated and installed at Mandapam, Kundukal, Munaikkadu, Maraikkayarpattinam and Thangachimadam of Ramanathapuram district. Additionally, the National Fisheries Development Board has supplied cages to fishermen beneficiaries from the coastal villages of Palk Bay and Gulf of Mannar during reported period for carrying out farming of marine fin fishes and shellfishes. The Mandapam Regional Centre of CMFRI has supplied fingerlings of cobia as well as facilitated the procurement of lobster juveniles for sea farming.

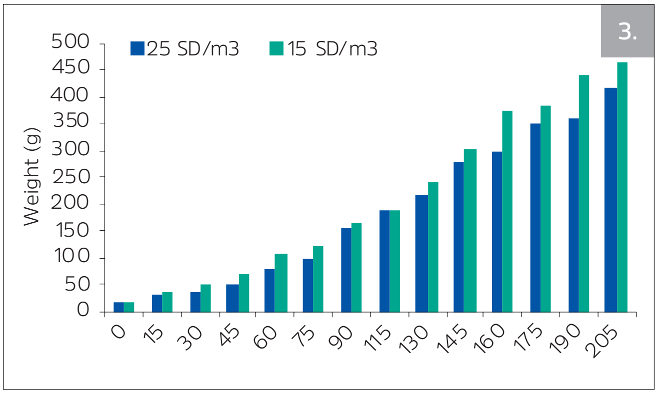
Immunization of grow-out fishes in sea cages

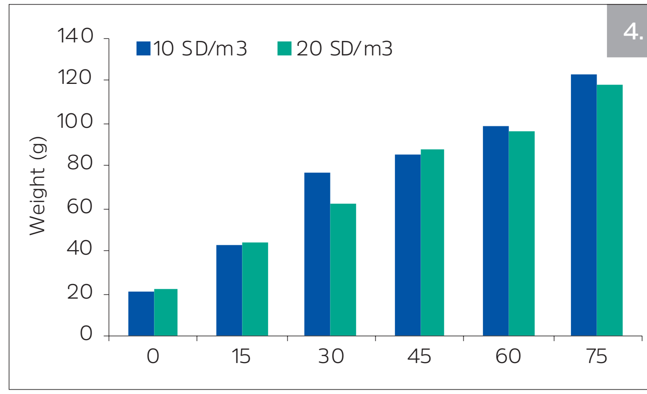
After the standardization of multivalent vibriosis vaccine in-vitro and experimental studies, the field application trials were carried out in the cage farmed cobia grow-out fishes. Sub adults (90 Nos.) and brood stock (35 Nos.) of cobia were vaccinated with Multivalent (*Vibrio alginolyticus*, *V. parahaemolyticus* and *V. harveyi*) algel adjuvanted vaccine followed by a booster dose after 21 days of the first dose. The serum antibodies were estimated and an increasing trend was observed from 7thday post vaccination (DPV) and continued up to 21 DPV. A decreasing trend of serum antibodies was noticed after 21 DPV and again an increasing trend from 35th DPV was observed.

The OD values of antibody to multivalent vaccine differed significantly ($P<0.05$) in the laboratory and in the field trial. There was a significant ($P<0.05$) increase in the OD values of antibodies from 7th to 21st day and dropped significantly ($P<0.05$) at 28 DPV. Hence, it was decided to administer one booster on 28 DPV. The 35th day OD value was higher than 21st and 28th day which indicated serum antibody OD levels were in increasing trend after the booster dose of the vaccine and the immunity was extended up to further 28 days. Thus, the regular epizootics observed in cage cultured cobia every year during the months of July to September (pre-monsoon season) was successfully prevented by immunization.

Intersex in cage farmed cobia, *Rachycentron canadum*

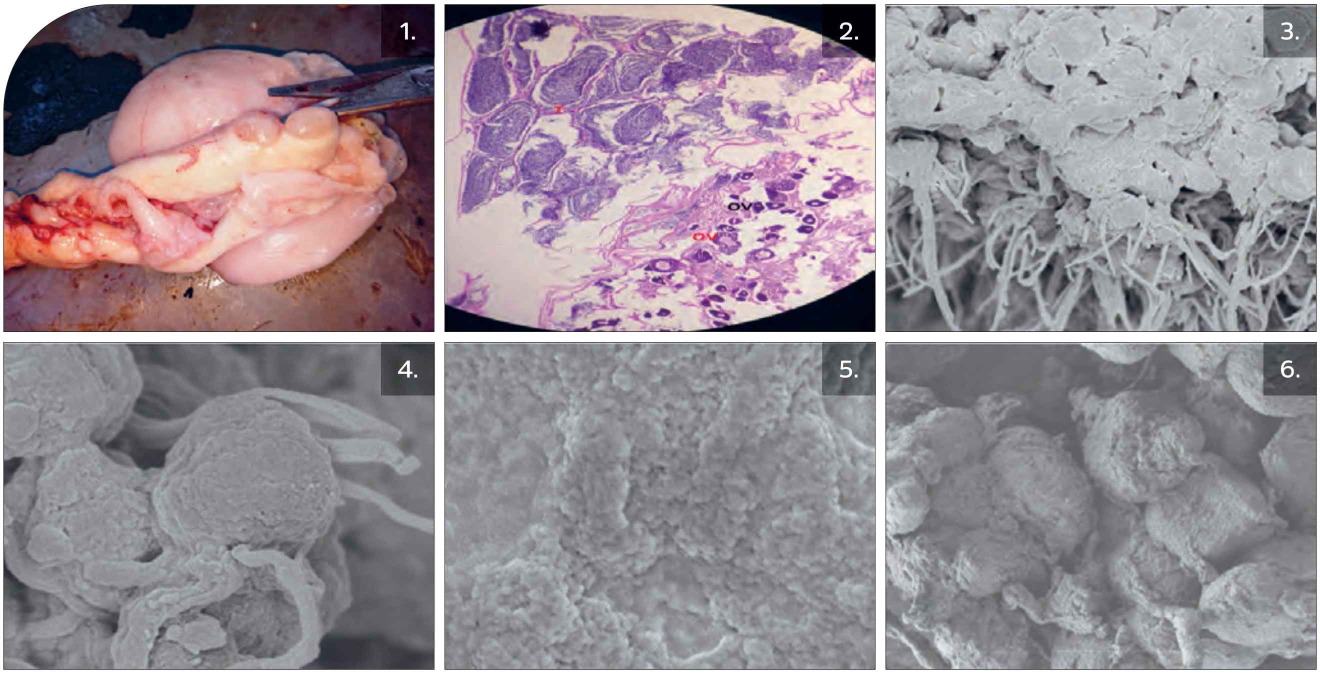
First observation of Intersex in Cobia (*Rachycentron canadum*) cultured in sea cages was recorded at Mandapam. A male cobia (assessed based on several cannulation biopsies) when dead, was found with a pair of testes with different morphological features (testes tissues





1. Growth of Indian Pompano in different stocking densities during nursery rearing in cage
2. Growth performance of orange spotted grouper in pond
3. Growth of orange spotted grouper stocked in different stocking densities in cages (25/m3 and 15/m3)
4. Growth of orange spotted grouper stocked in different stocking densities in cages 10/m3 and 20/m3)
5. Immunizing the fingerlings through vaccinator
6. Immunizing the grow-out of Cobia

embedded with nodular structures). The fish weighed 13.5 kg with a total length of 117 cm. Histologically, the section revealed both ovarian tissues and lumen of the seminiferous tubules with fully matured spermatozoa. The central part of the testes (non-nodular structure) revealed fully developed matured spermatozoa. But the nodular part showed majority of the ovarian tissues with minimal testicular tissues. This is the first observation of intersex gonads in the gonochoristic cobia from Indian waters.



Investigations of diseases and disorders in sea cage farming

Location	Period	Species affected	Percent mortality	Predisposing factor for the mortality	Cause of death
Pamban, Gulf of Mannar	May 2019	Cobia fingerlings (100-200g)	2.0	Occlusion by barnacles in the inner net and higher sea water temperature (33°C)	Higher temperature, and high stocking density
Mandapam, Gulf of Mannar	Sept 2019	Cobia fingerlings (200-250g)	36.5	Algal bloom *Noctiluca scintillans*	Acute hypoxia
Mandapam, Gulf of Mannar	Jan 2020	Pompano Fingerlings(80g)	20.0	Poor water quality	Stress and off-feed
Munaikaadu, Palk Bay	Feb 2020	Cobia grow-outs (1.0-2.5kg)	1.0	Poor water quality	Stress and off-feed

1. Gross: Gonad of cobia comprising of both testicular and ovarian tissues
2. Histology; T-Spermatozoa in the lumen of the spermatic tissue and OV- ovarian tissue primary developing oocytes in the same tissue. H7Ex100x
3. SEM picture Normal cobia spermatozoa
4. SEM: Normal cobia matured spermatozoa head and tail
5. Intersex male spermatogonia
6. Intersex male spermatogonia without development of spermatozoa
7. Fish health status investigation at Munaikadu, Palk Bay
8. Filtration Complex for RAS
9. Acclimatization to temperature
10. Acclimatization to salinity
11. Stocking silver pompano seeds in RAS tanks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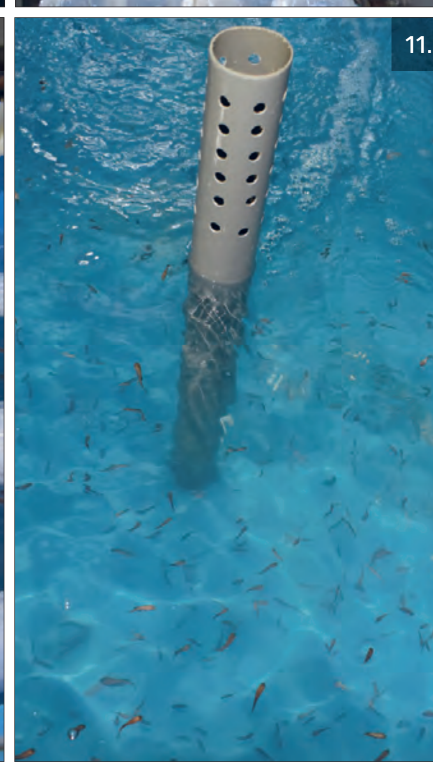
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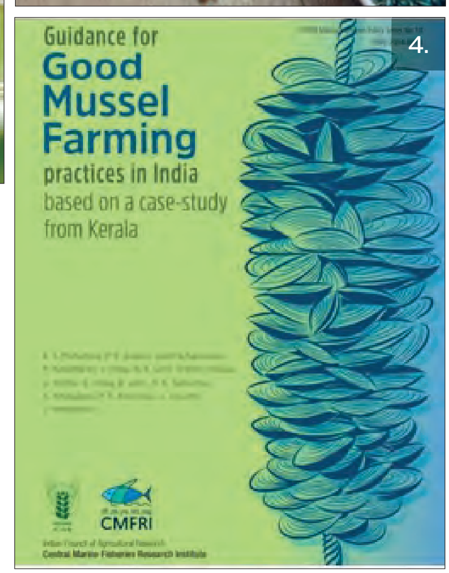
Bivalve culture

Farmed edible oyster, *Crassostrea madrasensis*, and green mussel, *Perna viridis* were harvested from Moothakunnam (Ernakulam District) and Chettuva (Trichur District) in June 2019. 1.8 tonnes of oysters and 6.75 tonnes of mussels were harvested and depurated in the Moothakunnam, Value Added Production (VAP) unit. The depurated and steamed oyster and mussel meat were sold through the ATIC of CMFRI @₹600/kg and ₹660/kg respectively.

The mussel seeds were minimal in the wild this season. Last year, due to the scanty rainfall pattern had resulted in higher salinity in the backwaters and a large number of seeds were available to the mussel farmers. This year due to the extended rainfall and lower salinity, the spat settlement was meagre and was not available to the farmers. As an alternative to mussel farming, the



1. Packing of pompano seed
2. RAS systems of the brood bank
3. Oyster farm at Padanna
4. Training on the seeding of mussel ropes at Sumana Estuary, Karnataka.
5. New green mussel farms at Chettuva (Trichur District)
6. Good mussel farming

1. Bivalve harvest, Kottaikadu. handing over to women beneficiaries

farmers have been encouraged to take up oyster farming and training in edible oyster farming was imparted to the farmers in Punjakkad in Kannur district and Ori in Kasargod District.

Oysters were harvested from farms in Sita-Swarna, Mulki, and Sumana Estuaries of Karnataka. The total harvest was 20 t of the shell-on oyster. The meat was shucked and marketed locally. Mussels from the farms located in Swarna-Sita and Sumana Estuary of Karnataka were harvested.

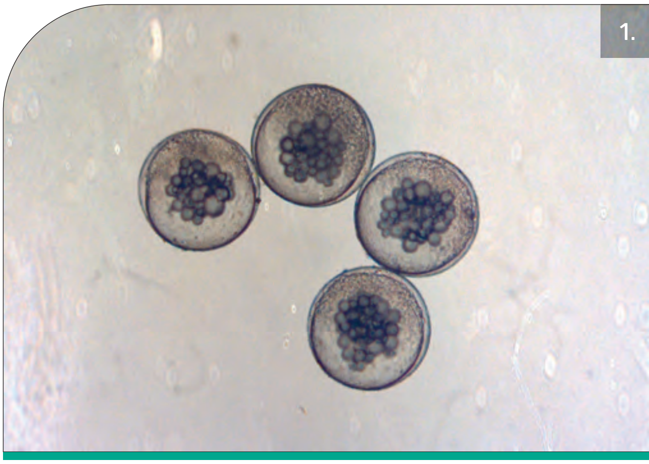
Samples of the black clam, *Villorita cyprinoides* were collected from various sites along the Indian coast for genetic stock identification. The complete mitochondrial genome of *Villorita cyprinoides* was sequenced using Next Generation Sequencing (Illumina Platform). The mitogenome was found to be 15,880bp in length. All the standard mitochondrial genes namely 13 protein-coding genes including ATP8, 2 rRNA, and 22 tRNA genes were identified. All the protein and non-protein-coding RNAs (rRNA and tRNA) were encoded on H strand (+ve) strand-like other bivalves.

Bivalve farming under the Fisheries Management and Sustainable Livelihood Project (FIMSUL – II, Component – II -1008892) was undertaken in three fishing villages *Viz*; Cuddalore Chinnakuppam (Kanchipuram district), Kottaikadu (Kanchipuram district) and Palavercadu (Thiruvallur district) in Tamil Nadu with technical guidance from Madras Research Centre of CMFRI, Chennai, for setting up farms. Beneficiaries were selected from the respective villages. Rafts were installed by the beneficiaries and oyster rens / seeded mussel ropes were suspended in the farms. The beneficiaries were trained to prepare oyster rens and installation of rafts.

All India network project on mariculture

Harvested *Lutjanus argentimaculatus*

Success was achieved in the development of hatchery technology for rabbitfish *Siganus vermiculatus*. Cage farming protocols for various high value marine food fishes were developed and demonstrated in the farmers field across the country.



Development of hatchery technology

Hatchery technology for *Siganus vermiculatus*

Hatchery technology for rabbitfish *Siganus vermiculatus* was developed by Karwar research centre of CMFRI. The wild captured fishes were reared in marine cage farm for broodstock development. The matured fishes were selected by cannulation and female fish with an average ova diameter of 420 µ and male fish with oozing milt were stocked @ 1:1 ratio in spawning tanks. Fishes were injected with Human Chorionic Gonadotropin (HCG). The fertilized demersal spherical adhesive eggs hatched out within 25 hrs duration. Fecundity was estimated as 1.85 lakhs with 68–71% of viable eggs and hatching rate was 73–85%. The larvae attained metamorphosis at 23-25 mm standard length after 36 days of rearing. Breeding trials following the first quarter of lunar cycle and during the period, a total of 7 induced spawning's were recorded and 697200 yolksac larvae were produced. Live feeds such as *Parvocalanus crassirostris, Brachionus rotundiformis, B. plicatilis* were used in larviculture. *S. vermiculatus* was also induced to spawn during the full moon period by intramuscular injection of two doses of HCG administered in 24 h interval. This is the first report of induced spawning of *S. vermiculatus* during full moon period of lunar cycle.

F1- Generation of Indian Pompano broodstock development

Fingerlings produced in the hatchery were reared in sea cages on artificial feed and fishes reached a size of approximately 3.0 kg after 2.5 years of rearing. 18 fishes were selected and stocked in re-circulatory aquaculture system at the sex ratio 1:2 (F:M) for maturation. Brooders were fed with broodstock diets mainly squid and clam meat incorporated with polychaete worms, vitamins and minerals. The brooders after 6 months of rearing started spawning naturally without hormonal induction with HCG. First batch of natural spawning was continued for nearly two-month period, during this period 8 consecutive natural spawning achieved with an interval of 4-8 days between spawning. Interval between two spawning was less in the initial period of spawning and later period the gap became more.

Non- response of brooders against repeated use of HCG

Muscle putrefaction was observed in Indian pompano brooders, which were continuously administered with inducing hormone, Human Chorionic Gonadotrophin (HCG) at finfish hatchery at Visakhapatnam. Indian pompano brooders were maintained in Recirculating Aquaculture System (RAS) for four-years and during the period, 22 spawning inductions were attempted. The brooders were responded well for initial 11 different inductions at an interval of 1.5 to 2 months period with HCG hormone @350 IU/kg body weight. However, after 11 injections, the brooders did not respond even after the dose of hormone was doubled. After this, the fishes were administered two dose of HCG @ 350 and 700 IU/ Kg body weight, however the same brooders did not respond. Instead, mortality of broodstock occurred with a symptom of non response to feed and muscle putrefaction at the dorsal region. The muscle putrefaction initially started at the region where the hormone administered and slowly spread in entire body.

Seed production of Indian pompano

A total of 1.5 lakh Indian pompano seed were produced (45,000 of advanced fingerlings and 1 lakh early fingerlings). The seeds produced were used for farming demonstration

1. fertlised eggs of *Siganus vermiculatus*
2. Larvae of *Siganus vermiculatus*
3. Muscle putrefaction in Indian pompano broodstock
4. Polyhouse based RAS nurseries for Indian pompano

projects supported by National Fisheries Development Board (NFDB). In addition, produced seeds were also supplied to the farmers of Andhra Pradesh.

Polyhouse based nursery rearing of Indian pompano

Poly house based RAS nursery was developed for rearing of Indian pompano to increase the growth rate in nursery phase. A total of 10 RAS tanks each with 10 ton capacity was used for nursery rearing and the entire unit was housed in a poly house. The poly house had helped to enhance the indoor temperature by around 3^{o}C compared to outer environment. The fry of 0.45g in size were stocked at density of 650/m^3, and fed with commercial floating diet of 45% crude protein and 10% crude fat at 8-10% body weight. The stocked advanced fry has reached a size of 8-9g after two months periods of rearing.

Vertebral deformities in hatchery produced Indian pompano

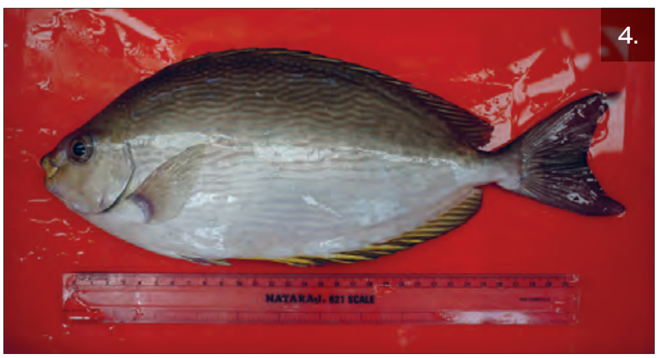
Study at Visakhapatnam centre revealed that in a batch of hatchery produced Indian pompano 4.4% of fishes had

musculoskeletal deformities. Among which 75.45% were manifested in the form of a deep depression in the musculoskeletal tissue anterior to dorsal fin, 17.27% of juveniles had the depression anterior to anal fin and 7.2% juveniles had the depressions anterior to both dorsal and anal fins. The photo-radiography examination revealed that the fishes with depression in dorsal and ventral fin region formed by fusion of dorsal spines 5-11, and anal spines 1-4, respectively. Fishes with depression in both dorsal and anal fin were affected by lateral and ventral curvatures of the vertebral column between 1-10th vertebral bones. A two months growth study revealed that the fishes of 31.62 ± 0.32 and 29.62 ± 0.18 gm had attained the size of 104.29 ± 0.28 and 102.36 ± 0.19 gm for deformed and normal fishes, respectively. The estimated growth parameters, SGR (1.86, 1.93% / day) and % WG (229.82 and 245.57) were not significantly differentiated (p>0.05) for deformed and normal fishes, respectively. However, the vertebral bone mineral content showed significant difference (p<0.05) between normal (35.65%) and deformed (32.23%) fishes. Similarly, the estimated calcium (Ca) and phosphorus (P) content in vertebral minerals of normal fishes (22.18% & 11.30%) were significantly high compared to the deformed fishes (20.45% & 10.02%). Plasma levels of Ca & P also showed significant difference (<0.05) between normal and deformed fishes. The study revealed that the minerals plays important role in vertebral deformities in fish.

Broodstock development and captive breeding trials

Sub adults of *Lutjanus rivulatus*, *Lethrinus nebulosus* and *Siganus javus* were reared in sea cages for developing broodstock at Mandapam centre. They were fed on special broodstock diets fortified with minerals and vitamins. Cannulation and egg biopsy studies were done for the developed broodstock at periodic intervals to assess the readiness to induction for captive breeding.

1. Vertebral deformities in hatchery produced Indian pompano
2. *Lethrinus nebulosus*
3. Cannulation of *Lutjanus rivulatus* produced Indian pompano
4. broodstock of *Siganus javus*
5. *Pomadasys furcatus* inside RAS
6. Cannulation



broodstock development of Rabbit fish *Siganus javus*

A total of 25 numbers of wild sub-adults of *Siganus javus* were stocked in cages at Mandapam for broodstock development. The collected sub-adult fishes were cannulated and are reared separately for maturation.

broodstock development of *Pomadasys furcatus*

Banded grunter (*Pomadasys furcatus*) of the family Haemulidae, were collected and reared in RAS facility at Vizhinjam center of CMFRI. The maximum size reported is 50 cm, and it showed good growth rate in RAS. Regular monitoring and ova-diameter assessment were carried out by cannulation of the broodstock.

Sea ranching of eggs of Pink ear emperor fish (*Lethrinus lentjan*)

Lethrinus lentjan broodstocks maintained at the Vizhinjam centre of CMFRI spawn volitionally throughout the

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year. About 1-2 lakh eggs per day were produced and excess fertilized eggs produced were regularly ranched in the sea with the help of fishermen and coastal police. Approximately 14 million eggs were spawned annually. Eggs and juveniles of the fish were transported to other centres of CMFRI for developing satellite rearing centre's.

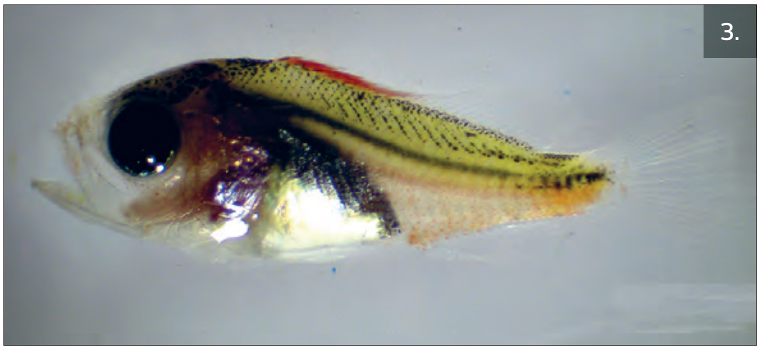
Egg and larval development of serranid fish Marcia's anthias, *Pseudanthias marcia*

The embryonic and larval development of volitionally spawned eggs of the serranid fish Marcia's anthias, *Pseudanthia marcia* (Randall and Hoover 1993) was described and illustrated based on observations during spawning, hatching and larval rearing trials. Eggs were obtained from volitional spawning of *P. marcia* under captive conditions in Re-circulating Aquaculture System(RAS).

Grow Out Culture

Comparative growth and biochemical responses of Indian pompano *Trachinotus mookalee* in different farming systems

Indian pompano*Trachinotus mookalee* culture in two different culture systems for the period of 300 days with an objective to compare its growth and biochemical responses were conducted. Two farming systems, pond culture and integrated cage cum pond culture were evaluated. In pond farming system, 3000 numbers of Indian pompano (35 g) were stocked in one acre pond. For integrated cage cum pond culture, four cages installed in a pond were stocked with total of 4000 fishes, @1000 numbers/ cage and 1000 fishes were directly stocked in the same pond. Initially fishes were stocked in 4x4x1 m cages



1. Sea ranching of eggs in Vizhinjam coast and the report in National daily
2. Handing over the pink ear emperor eggs to coastal police for sea ranching
3. Larval development of *Pseudanthias marcia*
4. Cage culture of Indian Pompano
5. Cage cultured Pompano

@40 numbers/m^3 till fish reaches 250 g and thereafter fishes were stocked in 8x8x1 m cages @15 numbers/m^3 for the remaining culture period. Fishes in pond and cage were fed four times in a day with pelleted feed containing 40-45% crude protein and 10% crude fat. The mean weight of the fishes after 10 months of the culture was 358±0.21gm, 584±0.08gm for pond and integrated cage, respectively. The grow performance in terms of absolute growth rate, AGR (g/day), specific growth rate, SGR (% / day) and feed conversion ratio, FCR were significantly ($p<0.05$) high for fishes cultured in integrated cage cum pond culture. The estimated serum biochemical parameter like glucose (45.12±0.5, 43.04±0.48 mg dL^{-1}) and cortisol (37.08 ± 0.125, 28.57±0.51 ng ml^{-1}) in pond and integrated cage were significantly different ($p<0.05$). Integrated cage cum pond could be adopted as an alternative method for fish culture to further enhancing fish production.

Cage culture of Indian pompano at different stocking densities

The advanced hatchery produced fingerlings of Indian pompano (Ave. weight 20g) were stocked in sea cages of 6 m dia and 4 m depth. The Indian pompano fingerlings were stocked at three different stocking densities such as 15, 25 & 30/m^3 to find out the effect of stocking density on the fish growth. The stocked fishes were fed with floating fish feed of 45% crude protein and 8-10% crude fat twice a day. Initially the stocked fingerlings were fed two times at 6-8% of body weight and slowly reduced to 3-4% according to growth stages. After 7 months of grow-out culture period, the fishes reached to the size of 648g, 508g and 410g for the stocking density of 15, 25 & 30/m^3 respectively. Interim result of the study showed that the stocking density has an impact on the growth of the species in cages.

1.

Cage farming of silver pompano in two ecosystems, *viz.,* Palk Bay and Gulf of Mannar

Sea cage farming of silver pompano in two ecosystems, *viz.,* Palk Bay and Gulf of Mannar was conducted to study the influence of water quality or other hydrodynamic parameters in these two ecosystems on the growth and survival of the farmed species. A total of four cages (114m^3)were installed with two cages each in both the ecosystems. The cages were stocked with seeds of silver pompano @ 20 fingerlings per m^3 having the mean length and weight of 68.89±10.05 mm and 6.41±2.61 g, respectively. The feeding was carried out with low value fishes initially @ 8- 10 % of total biomass which was gradually reduced to 5-8 per cent after 3 months of culture.

After 225 days of culture period, the final survival was 56% in Palk Bay and 65% in Gulf of Mannar. The total production in two cages each in Palk Bay and Gulf of Mannar was 783 kg and 1126 kg respectively. The results of the demonstration suggest that the

Growth details of Silver pompano in Palk bay and Gulf of Mannar

Culture Period	Mean Length (cm)		Mean Weight (g)	
	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar
Stocking size	14.6	59.0	14.6	59.0
90 days	18.9	90.5	21.3	112.5
135 days	19.4	126.5	23.0	166.3
180 days	23.2	225.6	25.6	288.8
225 days	25.6	335.3	28.1	412.8

1. Interchange the facing page picture with this picture - Harvested silver pompano from the cages
2. Farming of *Caranx* in sea cage
3. Cage cultured Orange spotted grouper

ecosystem had significant effect on the growth and survival of silver pompano.

Cage Farming Trials

Rabbitfish

Siganids (Rabbitfish) are primarily herbivores and this makes them an ideal species for farming from a sustainability perspective. A total of 650 numbers of wild collected seeds with average size of 19.6 g were collected from Palk Bay and were conditioned in onshore tanks after which they were stocked in 6 m diameter HDPE cage with 4 m depth net cage. They were fed with fresh seaweeds along with sinking pellet feeds @ 10 % of their body weight. Monthly sampling was carried out for growth assessment. The fishes attained the growth in terms of mean weight of 59.5 g, 116.2 g and 153.6 g in a culture period of 30 days, 60 days and 90 days, respectively.

Carangids

A total of 2500 wild collected fingerlings of *Caranx ignobilis,* with a mean size of 6.5 cm in length and 70.0 g in weight were stocked in 6 m diameter cage for sea cage farming trial in Gulf of Mannar. The feeding was carried out with low value fishes initially @ 8- 10 % of total biomass which was later reduced to 5-8 per cent. Periodic sampling was carried out to assess the growth. The fishes attained the growth in terms of mean length of 13.8 cm, 19.1 cm, 25.3 cm & 30.3 cm and mean weight of 125.2 g, 183.9 g, 242.5 g & 472.5 g, respectively in a culture period of 45 days, 90 days, 135 days and 180 days, respectively. After six months of culture period, survival was 72.5 per cent. The total production was 0.856 metric tonnes. The results of the demonstration indicated that the *Caranx ignobilis* can be a good candidate species for sea cage farming

and coastal mariculture. Cage culture of *Caranx spp.* was demonstrated at Kollam, Kerala in 6m diameter circular cages with farmers participation. The cages were stocked with juveniles collected from wild and grown to a size of 450-650g in 8 months.

Orange spotted grouper

Cage farming of Orange spotted grouper was demonstrated Karwar Taluk, Uttara kannada district with the participation of farmers. The fishes were fed with low value fishes collected from at 5 % of the biomass daily. After 7 months of culture, the fishes have reached an average weight of 1.05 kg (range from 600 g to 1.5 kg) with survival rate of 75%.

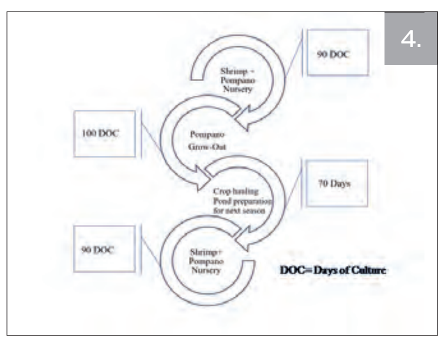
Red snapper

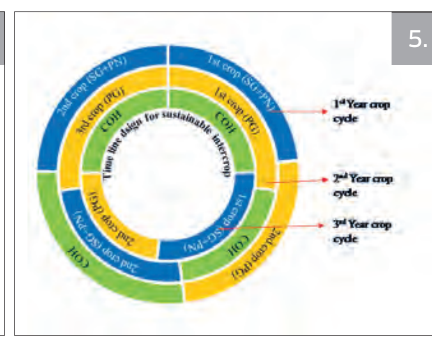
Red snapper farming in cages were demonstrated by Karwar centre and Vizhinjam centre of CMFRI. At Karwar farming was done 4x 4m rectangular cages and at Vizhinjam 6m diameter circular cages were used. Average initial weight of 100 g and stocked at an initial biomass of 0.3 kg / m^3, attained average weight of 125g at 30 DOC. Fishes attained a growth of 200-500g in 8 months. *Lutjanus argentimaculatus* were stocked in square shaped (6x6x4m) GI framecages installed at Morthota, Krishna district, Andhra Pradesh. Cages were stocked with red snapper fingerlings of size 5.6g. After 5 months, fishes grown to a size of 375 gms with a survival rate of 73%.

Pompano

Floating cages of 4x4m size (6 nos) were stocked with pompano seeds both *Trachinotus blochii* and *T. mookalee* at Kollam, Kerala in participatory mode. Juveniles having an average weight of 11g were stocked in these cages. During culture, mortality was observed due to isopod infection. The infection was controlled using Ivermectin incorporated through feed. Fishes reached 0.9-1.1kg (0.98) in 16 months trial for *Trachinotus blochii* and 1.58-2.12 kg (1.95) for *T. mookalee* in 16 months trial. Silver pompano, *Trachinotus blochii* farmed in circular cages of 6m diameter reached 1.0-1.5kg from the initial stocking size of 10.5 g during a demonstration culture at Kollam, Kerala.

Farming of silver pompano in cages were demonstrated at Morthota, Krishna district, Andhra Pradesh. Square shaped (6x6x4m) cages with Galvanised iron frames were installed and stocked with silver pompano fingerlings of





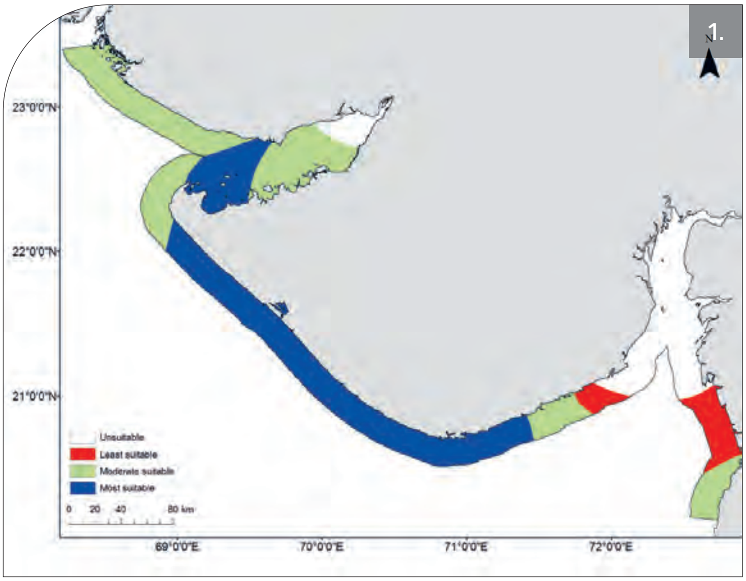
1. *Lutjanus argentimaculatus*
2. Sampling of *Trachinotus mookalee* for measurements
3. Pompano farming at Visakhapatnam
4. Intercrop cycle diagram
5. Timeline design for sustainable intercrop

size 7.5gms. Fishes were fed with the commercial pellet feeds and after 4 months, fishes grown to a size of 125 gms with a survival rate of 60%.

Asian seabass

A total of 9 cages (3 circular GI cages and 6 rectangular cages) were installed at various places in Uttara Kannada district under the project for demonstrating Asian seabass culture. Circular cages were stocked with seabass juveniles @2000/cage and rectangular cages @1000/cage. The stocking size of juveniles were 12 cm.

Farming of Asian seabass was demonstrated in 5 cages, installed at Nachugunta, Krishna District, Andhra Pradesh and 2 cages at Morthota, Krishna district, Andhra Pradesh. Demonstrations were carried out in circular cage of 6m diameter and square type cages of 6mx6m at former site and 4x6x4m cages at latter site. Wild collected Seabass juveniles were introduced in the cages. Fresh fish, cut into pieces was used as feed for the seabass. At Nachugunta, fishes showed a growth of 152 g in 3 months, whereas at morthota, 383.43g in 5 months.



The result of farming of seabass in cages installed at Kalnagini estuary at Banshtala Ghat, Kakadwip, South 24 Parganas district of West Bengal showed a growth increase of 330g in weight and 11.6 cm in length after 4 months of rearing.

Mullet Cephalus

Cage culture of *Mugil cephalus* was initated in Bahuda estuary of Ganjam District, Odisha. Two nos of GI cages and one HDPE cage will be installed in the Bahuda estuary for farming of mullet juveniles in cages for table size fish production. Farming of mullet (*Mugil cephalus*)in cages were demonstrated in cages at Suryalanka, Guntur district, Andhrapradesh. Fishes recorded a growth of 32.2 g in 3 months when reared in square shaped cages of 6x6m.

Intercropping of marine finfish and shrimp

Diversification of shrimp farming with marine finfish in a farmer participatory research mode was attempted. The Silver pompano, *Trachinotus blochii* was intercropped with Pacific white shrimp, *Litopenaeus vannamei* culture in coastal shrimp ponds was assessed for growth, survival, and economic viability. During the grow-out period of 100 days, fishes grew from 40.23 ± 1.40 g to 256.56 ± 1.08 g in weight and 12.83 ± 0.19 cm to 25.11 ± 0.09 cm in length. The daily weight gain (DWG) and daily length gain (DLG) were 2.16 g/day and 0.12 cm/day, respectively. Relative growth rate (RGR) and specific growth rate (SGR) recorded for weight was 537.80% in 100 days and 1.85% per day, respectively. Pompano has exhibited its sturdiness and adaptability to the land-based culture system as evidenced by an overall survival percentage of 89.8% including nursery and grow-out phases. The realized feed conversion ratio was 1.94. The culture period of 100 days is found to be enough to attain a desirable harvest size of 250 g. The projected production potential of the experimental demonstration farm of 4500 m^2 water spread area for culture was 16.2 tonnes/cycle with a benefit-cost ratio (BCR) of 1.34 over operational cost. The present participatory trial empirically proved

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1. Physical suitability model map
2. Training programme on cage culture of marine finfishes
3. AINP SCSP beneficiary feeding the pompano in cages
4. Seaweeds – ready for harvest

the viability of Silver pompano as an intercrop in coastal shrimp ponds.

GIS based spatial model for identifying potential mariculture sites along Gujarat coast

For the mariculture development in the state of Gujarat, a preliminary Geographic Information System (GIS) based decision support model and a spatial framework has been developed for site selection of cage farms in the territorial waters along the coast of Arabian Sea. The transit trajectory of 20 km territorial waters accounts to about 30000 km^2 area was examined under the project. The preferable biological and oceanographic parameters for the culture system and candidate marine fish species were used for the decision-making analysis. The developed comprehensive model consists five sub-models viz., topographic, physical, chemical and biological oceanographic and socio-infrastructural models. The model explored and demarcated suitable sea space of 12600 km^2 for mariculture, emphasizing the untapped potential of the available open waters of the Gujarat state. Further, the present spatial decision support model, in particular to its methodology and framework, allows for identifying the best suitable sites for mariculture along the territorial waters of the country.

Skill development programmes

Two training programmes on cage culture and nursery rearing of Mugil were conducted in the village of Markandi of the Ganjam District, Odisha by College of Fisheries (OUAT), Rangailunda, Odisha. Training programmes were attended by 80 fishers.

Three training programmes were conducted by Fisheries Research Station, Sri Venkateswara Veterinary University, Kakinada, on 'cage culture' at 1. Nachugunta Krishna District 2. Ramapuram near Edurumondi, Krishna District and at 3. Karlapalem, Guntur District., Andhra Pradesh. Each training programme was conducted for 30 fishertolk. Training material in Telugu was prepared and distributed to the trainees.

ICAR-Central Island Agricultural Research Institute Port Blair conducted 7 days training programme on “Entrepreneurship Development through Mariculture at ICAR-CIARI, Port Blair. Altogether 12 participants from South Andaman were participated in the seven days of training programme.

A three days skill development training program on cage fish farming was conducted at Fisheries Research & Information Centre (Marine), Ankola for the potential fish farmers of the region. 36 fish farmers participated in the program.

Activities under Scheduled Caste Sub-Plan Component

Vizhinjam

Under AINP SCSP unit, 8 nursery cages of different sizes were established and being operated by beneficiaries. The first trial with metamorphosed fry of 10,000 numbers pompano yielded 5450 fingerlings of stockable size (10-15g) within 2 months period.

Mandapam

The Mandapam regional centre of ICAR-CMFRI has selected Puthukudi village, Thondi in Ramanathapuram district of Tamil Nadu for implementation of Scheduled Caste Sub-Plan (SCSP) project since it has 97 per cent of SC families in the total village population. Two beneficiary groups (3 fishers in each group) was selected for undertaking seaweed farming activities. For each fisher, 21 monoline units of seaweed provided for farming. Marketing tie up with seaweed processing units were also arranged for marketing their produce.

Kochi

Four cages (4x4m) were given to 2 beneficiary groups were given for farming of seabass and pearl spot. Inputs for one crop like seed for stocking and feed were given the groups.

Visakhapatnam

Hands on training programme on ‘cage culture of finfishes was conducted for three days at Edurumondi, Nagayalanka Mandal, Krishna District, Andhra Pradesh by ICAR-CMFRI, Visakhapatnam regional centre. The training programme was organized with an aim of developing skills on fabrication of cages and culture of marine finfishes in cages and attended by 25 participants.

Veraval

Three day training programme on ‘Cage culture of finfishes’ was conducted by Veraval regional centre of ICAR-CMFRI. The training programme was attended by fishermen/fishers of that area. The training programme helped the beneficiaries to obtain basic understanding on culture of marine finfishes in cages.

Karwar

Two SHG’s were identified from Bhatkal Taluk of Uttara Kannada district and were given two numbers of rectangular GI cages per group. Hatchery produced Asian seabass seeds were given to the groups for stocking in cages and feed required for one crop was also given to beneficiaries.

Marine Biodiversity

Project MBD/CNS/30

Bruguiera cylindrica- Kadalundi vallikunnu community Reserve

Developing conservation plan for biologically sensitive areas along the Indian coast

Maharashtra

Dharamtar creek assumes importance and known for *Macrobrachium rosenbergii* and *M. bombayensis* and Hilsa fishery. Dabhol creek is known for the high bird population and tourism. Domestic and industrial effluents from MIDC area reduces the biodiversity. Kalbadevi creek assumes importance for the rich molluscan resources: *Meretrix meretrix, M. casta, Paphia malabarica*, *Katelysia opima, Crassostrea madrasensis, Saccostrea cucculata*, known habitat of seahorses and 11 species of true mangroves. Bangkot creek assumes importance for its rich mangrove habitat, rich turtle nesting and heritage.

Karnataka

Mulki Rocks, also known as Primeira Rocks is a rocky patch off Kaup in Karnataka is located nearly eight km off the coast of Kaup beach. This area is well known as spawning and nursery ground of many commercial food and ornamental fin and shellfishes.

Kerala

In North Kerala, studies were conducted at Kadalundi, Korappuzha, Thikkodi, Kolavipalam and Dharmadom estuaries. All the study areas scored high for the criteria 'Special importance for life-history stages of species, Vulnerability, fragility, sensitivity and slow recovery, Biological diversity, Biological productivity and Ecosystem functions. Kadalundi and Korappuzha estuaries scored low on 'Naturalness', while Thikkodi, Dharmadom and Kolavipalam scored high for this criterion.

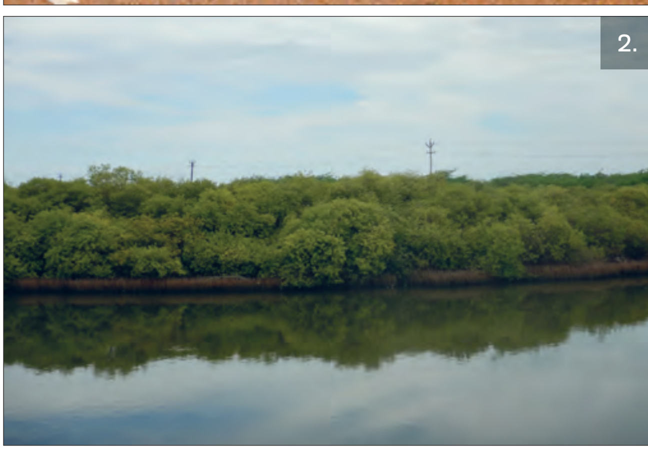
The Kadalundi wetland scored high for the criterion 'Importance for threatened, endangered and declining species and/or habitats', due to the presence of the smooth-coated otter *Lutrogale perspicillata* (Schedule II of the Indian Wildlife Protection Act, 1972 & Appendix II of CITES), the ocean turf grass *Halophila beccarii* (listed as VU in the IUCN Red List of threatened species) and the avian faunal diversity which includes 21 migratory species and 40 resident fauna.

The Purakkad beach serves as an important extended staging grounds for a good population of sea and shore birds. It is an important wintering grounds for migratory birds. A total of 65 species have been recorded of which 20 are shore birds and 15 seabirds. Poovar-Pozhiyur: Mangrove cover more than 50 acres and has a rich diversity of 24 species. One species of mangrove *Barringtonia racemosa* has distribution in Poovar.

Tamil Nadu

Punnakayal and Palayakayal estuaries are confluence of the perennial river Thamirabarani. This area is well known for mangrove patches and mud flats. It is an excellent foraging ground for birds. Fishery, oyster picking and collection of annelid worms for shrimp hatcheries are the prominent provisioning services of this area. Pantry estuary in Kanyakumari district is known for its rich mangrove vegetation dominated by *Rhizophora* sp., besides resident and migratory avian fauna.

Manakudy estuary, a confluence of the river Pazhayar is characterised by the presence of mangrove forests and a good bird population. Collection of shrimp and fish seeds is one of the major income generation activity of fishers of the locality. Udhayamarthandapuram bird sanctuary is a protected area located in Thiruvarur



1. Cattle egrets and little egrets feeding at the shrimp drying area in Thottapally beach, Kerala
2. Mangrove at Palayakayal, Tamil Nadu
3. Migratory birds at Pantri estuary, Tamil Nadu

District of Tamil Nadu. It was declared as a protected area in December 1999. The Point Calimere Wildlife and Bird Sanctuary is situated on a low promontory on the Coromandel Coast in Nagapattinam district, Tamil Nadu. In 1967, the forests of Point Calimere with an area of 24.17 km^2, was declared as the Point Calimere Wildlife Sanctuary.

Andhra Pradesh

Bhairavapalem is characterised by estuary, open sea, mangroves, backwaters and creeks. The landings of sharks and other elasmobranchs are very high. Pudimadka is a fishing village in Visakhapatnam district. The total area of major habitat is about 3.94 km^2. Vulnerable: elasmobranchs like *Rhynchobatus djiddensis, Himantura uarnak,* and *Manta birostris* were

recorded. Schedule I species like the sea horse (*Hippocampus kuda*) and the marine turtles (*Lepidochelys olivacea, Chelonia mydas and Dermochelys coriacea*) are common. Endangered elasmobranchs like *Aetomylaeus maculates* and *Mobula diabolus* are also common.

Investigations on the Scyphozoan and Cubozoan jellyfish diversity and distribution along the Indian Coast

Research Project (MBD/JLY/32)

Jellyfish Diversity

Along Tamilnadu coast, Jellyfishes were collected from fishing villages of north Tamil Nadu, along Besant Nagar, Devanerikuppam, Soolerikattukuppam, Chemmenchery kuppam and Kadalur alikuppam. The composition of collected jellyfish samples (n= 702) comprised of 10 species, nine genera, and three classes. Seven Scyphozoan, one Cubozoan and two Hydrozoan jelly fishes were recorded.

The *Chrysaora* sp. which is known for its painful sting reappeared in coastal waters during January – February 2020 and they were also found in some of the estuaries of North and central Kerala coast, including Kadalundi, Korappuzha and chettuva estuaries during this period. *Crambionella orsini*, a commercially valuable species was found in stray numbers along with *Chrysaora* sp. in ring seines operated off Chaliyam at a depth range of 10-40m during the first week of October, 2019. The average bell diameter of *C. orsini* was 98 mm while the average length of oral arm was 56 mm.

Jellyfish fisheries

The quantity of jellyfishes landed by the fishing vessels in Gujarat in 2019-20 is around 4.5 thousand t valued around ₹5.4 Crore which is 30% low as compared to the year 2018-2019. The total quantities of this edible jellyfish caught by motorized crafts were estimated as 55,181 tonnes along the coast of Andhra Pradesh during 2017-19. The highest catch was in 2018, wherein 33,273 tonnes were landed. Altogehter four species dominated in the fishery: *Crambionella annandalei*, *Crambionella orsini*, *Catostylus perezi* and *Rhopilema hispidum.*

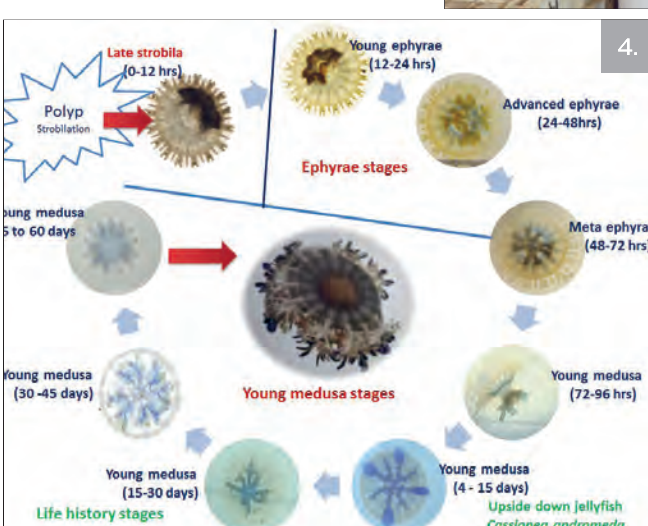
The estimated value of oral arms of jellyfish at landing centre level was highest at ₹4013 lakhs ($5.65 Million) in 2018 whereas, the lowest estimated value was ₹20 lakhs ($0.02 Million) in 2019.

Lychnorhiza malayensis also started appearing in August 2019, with large swarms in October 2019 in coastal and estuarine waters. *Acromitus flagellatus* was found in large numbers in Kadalundi and Korappuzha estuaries during January and February, 2020. During this period, the stake net fishing operation was affected at Korappuzha where an average number of 9 stake nets were operated. In a fishing operation of 3 hours per day, an average number of 250 jelly fishes were found in each stake net of which 90% comprised of *A. flagellatus* and the rest were *Chrysaora* sp. The species *Cyanea lamarckii* and *Cyanea nozakii* were also observed during August-October months, with large numbers occurring during October, 2019. *Aequorea* sp. was found to appear in December 2019.

Redescription of the enigmatic jellyfish, *Crambionella annandalei* (Cnidaria: Scyphozoa) from Indian waters

The catostylid jellyfish, *Crambionella annandalei* was originally described by Rao (1932) based on a preserved

1. Mangroves at Godavari estuary
2. Jelly fish catch in shore siene
3. Cleaning of oral arms
4. Life history stages of *Cassiopea andromeda*
5. *Acromitus flagellatus* an estuarine swarming jellyfish in Karnataka



specimen collected from the Andaman Sea. Since then, no detailed taxonomic studies have been conducted and the species is often misidentified. A detailed morphological re-description of *C. annandalei* was made from fresh specimens collected at a variety of locations along the east coast of India under this project. The species can be distinguished from its congeners by a combination of morphological characters, the most important of which are the proportion of terminal club length to oral arm length (0.48±0.031), the proportion of the distal portion of the oral arm to naked proximal portion (7.25±0.268) and the body colour.

Technology Package Developed

"JellySafe"- First aid kit for jellyfish sting management has been developed under the project MBD/JLY/32.

Public Advisory Boards

Two public advisory boards have been established at Arichalmunai and Ariyaman beach for the benefit of fishers and tourists on jellyfish sting and their first aid management. Stakeholders meet was arranged to sensitise on the jellyfish menace and their sting management.

Assessment of resilience potential of coral reefs of India

Research Project (MBD/CRL/31)

Coral Diversity

Surveys were made at Havelock and Neil Islands of Andamans during December 2019. A total of 124 species under 37 genera belonging to 15 families of reef building corals were identified. *Acropora* dominated the recorded hard corals with 30 species followed by *Porites* (11) *Dipsastrea* (10), *Montipora* (7), and five each in *Goniastrea, Favites, Platygyra* and *Fungia*. Heavy sedimentation observed in most of the sites with large scale mortality of hard corals. A healthy fish fauna was found associated with the corals. 82 species of reef fishes under 50 genera belonging to 23 families were identified from the photographs and videos taken during scuba diving. Pomacentridae with 19 species and Labridae with 15 species dominated the reef fishes recorded.

Underwater survey was conducted in the reef flats and fore reefs of Kavaratti atoll. Data on the benthic functional groups, resilience indicators and coral diversity were collected from 12 stations. Survey was made at the reef flats and fore reefs of Chetlat atoll during December 2020. A massive single species stand of Blue Coral *Heliopora caeurulea* occupying 48% of the total reef area was recorded. Survey data on the Agatti, Chetlat and Amini atolls were analysed to study the secondary successions. A comparison with the previous surveys indicated a widespread outgrowth of Anemone over the hard corals in the northern Agatti region. Disease incidences were prevalent in the Amini atoll with Pinkline syndrome as the major incidence.

Plankton Diversity

Phytoplankton and zooplankton collected from four stations off Pitty Island were analysed. Of the four stations two stations were located in inshore waters and two were in oceanic regions. Among the phytoplankton, diatoms dominated with 28 species followed by dinoflagellates

Coral Diseases

Coral diseases such as Black Band disease, White patch syndrome, Yellow Band disease, White band disease, Pink Line disease and White syndrome were observed in kalpeni island. Extensive tissue loss was also observed in the surveyed stations. Relatively higher

1. Mono specific stands of blue corals at Chetlat atoll

Macro algal coverage was observed in Kalpeni than other Islands. Out of 22 stations surveyed 10 stations are found to be having high resilience capacity.

Sea Bird Diversity

Hints about the species of birds breeding in monsoon on Pitti was obtained, though indirectly from a post monsoon survey. Eggs and juveniles of other species (Sooty tern, Greater and Lesser crested terns) other than Brown noddy were observed. Two Palearctic breeding migratory species were recorded for the first time in Lakshadweep–Eastern Common Swift (*Apus apus pekinensis*) and European Bee-eater (*Merops apiaster*).

A total of 43 species of birds were observed from the three islands of Kavaratti, Kalpeni, Chetlat and from the waters around the islands during the three visits. Many of these are winter migrants from the high Arctic Eurasian region. This include important shorebirds of the families Charadridae and Scolopacidae. Oceanic birds like Swinhoe's storm petrel (Breeds in the islands in Sea of Japan) and Wilson's storm petrel (Breeds in the islands of Southern Indian Ocean and Antarctica) were also observed beside vagrants like Lesser Frigatebird.

Molecular taxonomy and phylogeny of Cones (cone snails) and Strombs (Mollusca, Gastropoda) of the Indian coast

Funded Project (DBT)

During the period total of 20 species (57 individuals) from the families Conidae and Strombidae were collected from nine sampling sites along both the coasts of India including Andaman and Nicobar Islands.

Fragments of the mitochondrial genes 12S rRNA, 16S rRNA, Cytochrome oxidase subunit I (COI) and nuclear H3 gene were amplified. All genes

1. Molecular Phylogenetic analysis by Maximum Likelihood method (Mitochondrial COI)
2. *Acanthus ilicifolius*-flowering –KVCR Kadalundi
3. Patch of *Sonneratia alba*–KVCR Kadalundi

were sequenced in both directions for increased accuracy. Molecular sequence data from three mitochondrial gene regions (16S rRNA, 12SrRNA and cytochrome oxidase subunit I) and a nuclear gene (Histone 3) to resolve phenotypic plasticity among the *Conus (Pinoconus) catus* in varying ecosystems of Andaman and Lakshadweep archipelagos were developed. Maximum likelihood clustering approaches were done based on mitochondrial genes, COI (658bp), 16s rRNA (540bp), 12s rRNA (460bp) and Nuclear H3 gene (360bp) amplified in the specimens of varying phenotypes of *C. catus*. The analysis revealed that *C. catus* shows exceptional phenotypic plasticity among ecosystems without any genetic modification. This current plasticity could be the outcome of epigenetic factors associated with ecological adaptation.

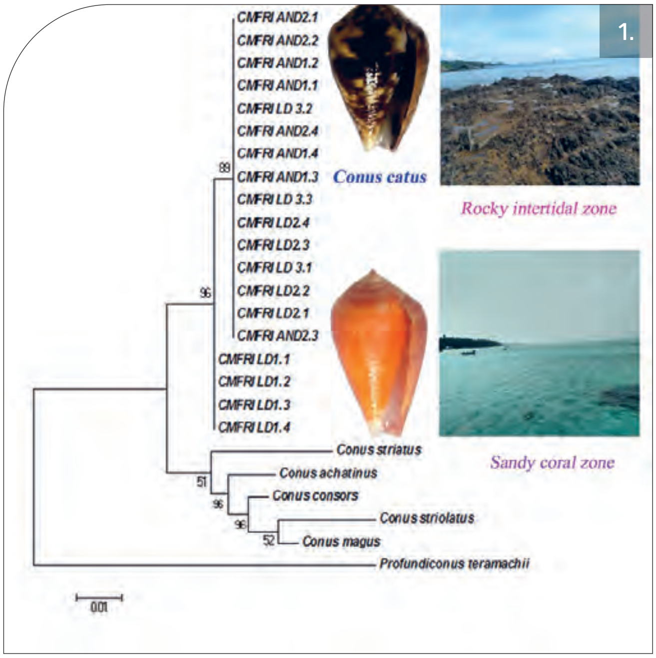
Unexpected cryptic diversity observed in some cone species among the populations of Indo pacific and Laccadive Sea. Present study also provides new leads that commonly used COI markers do not facilitate to differentiate the representatives of two genus of strombidae.

Integrated taxonomy reveals the exceptional phenotypic plasticity in *Conus (Pinoconus) catus* among the Andaman and Lakshadweep archipelagos. Species delimitation in the cone snails has long been difficult, because of its extraordinary taxonomic and ecological diversity. Shell characters and primarily colour patterns are the basic taxonomic features.

Valuation of marine and coastal ecosystem in Kadalundi Community Reserve of Kerala Biodiversity Board

Funded Project (Kerala Biodiversity Board)

The estuarine wetlands are critical ecosystems that are highly productive and play a crucial role in coastal fisheries. The Kadalundi-Vallikunnu Community Reserve (KVCR) is the first Community Reserve of Kerala, declared in October 2007, and lies partly in Kozhikode and Malappuram districts of the state. The Community Reserve which has a total area of 153.84 ha is characterised by the presence of mangroves, mud flats and rich biodiversity. The project was envisaged to document the biodiversity of KVCR and to delineate the value of various ecosystem services rendered by this wetland.



Among the phytoplankton groups, Bacillariophyceae was abundant throughout the year; however, Dinoflagellates showed its abundance during August and September 2018 and in January 2019. A total of 29 groups of zooplankters were recorded from the Kadalundi estuary. Copepods formed a maximum of 39% followed by *Balanus nauplii* (13%), Cladocera (11%), prawn larvae (10%), crab larvae (6%), fish larvae (5%), while the remaining groups constituted less than 4% each. The polychaetes, crustaceans and molluscs formed the major macrobenthic fauna. The Beccari's seagrass, *Halophila beccarii* which is listed as Vulnerable in the IUCN Red List of Threatened Species has been recorded in the Kadalundi wetland.

A total of seven species of mangroves *viz*., *Avicennia officinalis, Avicennia marina, Rhizophora mucronata, Sonneratia alba, Bruguiera cylindrica, Excoecaria agallocha* and *Acanthus ilicifolius* were recorded from the Community Reserve. Of these, *Avicennia officinalis* was the predominant species. Besides, mangrove associates like *Derris trifoliata, Acrostichum aureum, Volkameria inermis, Premna serratifolia,*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Terminalia catappa, Thespesia populnea, Cerbera odollam and *Morinda citrifolia* were recorded.

A total of 13 species of molluscs were found to inhabit the Kadalundi estuarine wetland which belonged to 13 genera under nine families and seven orders. The edible oysters *Saccostrea cucullata* and *Magallana bilineata* (= *Crassostrea madrasensis*) were commercially exploited. The invasive species *Mytella strigata* has been found to have gained entry into the Kadalundi estuary.

A total of 69 species of avian fauna were recorded which belonged to 51 genera, 28 families and 12 orders. Of the 69 species, 39 species were resident fauna, one species i.e. the black-headed Ibis, *Threskiornis melanocephalus* shows local migration, while the remaining 29 species are migratory. A total of 59 species of finfishes were recorded which belonged to 39 genera, 33 families and 10 orders. The smooth-coated otter *Lutrogale perspicillata* listed as Vulnerable (VU) in the IUCN Red List of Threatened Species has been recorded in the Kadalundi wetland. About 12-15 numbers of this mammal were regularly spotted in the Reserve.

The economic value of different ecosystems of KVCR including the


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1. Reef heron- KVCR Kadalundi
2. Black headed Ibis– KVCR Kadalundi
3. *Hyattella repandus* Varsha, Joshi & Jasmine, 2020
4. *Hyattella macrophylla* Varsha, Joshi & Jasmine, 2020
5. *Hyattella foliata* Varsha, Joshi & Jasmine, 2020
6. *Hyattella vedalainensis* Varsha, Joshi & Jasmine, 2020
7. *Hyattella diffusa* Varsha, Joshi & Jasmine, 2020


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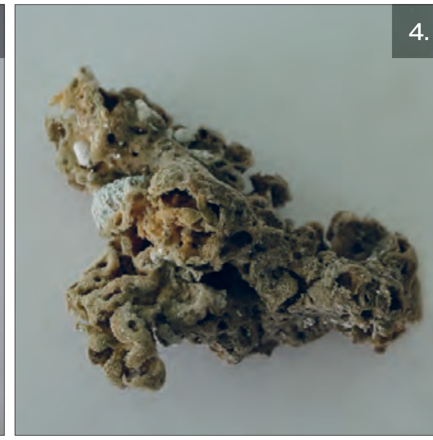
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adjacent open ocean was estimated. The Kadalundy estuary alone is estimated to have a value of ₹2.32 milllion and the mangrove ecosystems have a value of ₹2.55 million and Total Economic value of KVCR was ₹56.11 million.

The major issues studied in the present project includes the sand bar formation at the bar mouth, sand accretion in mud flats, pollution due to plastics and dumping of slaughter waste. Based on the studies conducted several management measures have emerged and suggested to KSBB such as removal of sand from the bar mouth, planting of mangroves, creation of mangrove nurseries capacity building to local people and creation of an interpretation centre.

Taxonomical Investigation of lesser known marine animals of India- Phylum Cnidaria (Class: Anthozoa) and Phylum: Porifera (Marine)

Funded Project (MoEFCC)

Survey and inventorisation of Sponge resources were done from Kovalam (30), Pitty (5), Kavarathi (19), Mandapam (21), Thirupalaikudi (69), Thonithurai (5), Vadalai (45), Mottagopuram (25), Vellappatti (59), Pattinamaruthr (17), Sippikkulam (9), Veerapandiyapattinam (7), Kulasekharapattinam (11), Alanthalai (4), Manappad (11), Periathalai (6), Kayalpattinam (21), Gulf of Kutch (61), Visakhapatanam (3), Devanerikuppam (2), Chetlat (10), Muttom (3), Kadiyapattinam (17) and Andaman & Nicobar (5).

Spicules of 465 specimens of sponges were extracted and analysed using light microscopy and measurements were taken. Detailed investigation on *Hyattella cribriformis* (Hyatt, 1877), *Hyattella cavernosa* (Pallas, 1766), *Hyattella intestinalis* (Lamarck, 1814), *Hyattella sinuosa* (Pallas, 1766) and *Hyattella globosa* Lendenfeld, 1889 were done and species identification was completed.

Underwater surveys were conducted at Keelakarai, Kayalpatinam, Agathi, Vizhinjam, Kovalam, off Okha, Mithapur, Shivrajpur, Poshitra, Beyt Dwarka and sponge samples were collected. Sea anemone samples were collected from Thirupalaikudi of Gulf of Mannar, Kovalam and Vizhinjam for taxonomic studies.

Six new species *Hyattella repandus* Varsha, Joshi & Jasmine, 2020 (Holotype: CMFRI. DNR. No. BA.1.1.2.8), *Hyattella macrophylla* Varsha, Joshi & Jasmine, 2020 (Holotype: CMFRI. DNR. No. BA.1.1.2.10), *Hyattella foliata* Varsha, Joshi & Jasmine, 2020 (Holotype: CMFRI. DNR.No.BA.1.1.2.14), *Hyattella vedalainensis* Varsha, Joshi & Jasmine, 2020 (Holotype: CMFRI. DNR. No. BA.1.1.2.12), *Hyattella diffusa* Varsha, Joshi & Jasmine, 2020 (Holotype: CMFRI. D.N.R. No. BA.1.1.2.13) and *Hyattella oblongus* Varsha, Joshi & Jasmine, 2020 (Holotype: CMFRI. DNR.No.BA.1.1.2.11) were added to the fauna of India.

Marine Habitats

Soil erosion at Kunthukal beach

Real time data generated for five projects on coastal and marine environment including aquatic pollution and its abatement measures

Micro-level environmental management plans for selected critical habitats for ecosystem health and sustainable production

Research Project–FEM/HBT/27

The Ecosystem Health Index (EHI) developed was used to monitor the selected coastal ecosystem during the post-monsoon, pre-monsoon and monsoon seasons. Protocol for participatory approach for the plastic litter management was developed and the same is implemented successfully in ward numbers 8 and 9 of Mulavukad Gramma Panchayat and every month) 200 kg of plastic was collected and handed over to recyclers.

At Thoothukudi, the survey on waste generation, disposal and management in the Panchayat area indicated a higher level of contribution from households than the industries and public places. Bio-waste comprised a significant portion of the household waste. Sensitive habitats like mangroves and seagrass beds were assessed for ecosystem health in Gujarat for the development of sustainable micro-level environment management plans (EMP). The mangroves of Porbandar were found to be at high risk of pollutants from domestic and industrial sectors. High rate of sedimentation due to harbour and jetty developments along Gujarat coast have been found to be destructive to seagrass beds. Increase in oil spillage from the tankers, ships and sub area pipelines from the different industries were also found to affect seagrass beds.

Mangrove sites in Mangalore were assessed for the ecosystem health and the region were graded based on water quality index. Awareness campaign regarding the importance of mangroves and the influence of fresh water inflow into the region helped to improve the water quality of this area.

Ecosystem health of Korapuzha Estuary, Kozhikode was assessed based on abiotic and biotic factors and the impact of plastic pollution on traditional fishery in this region was evaluated.

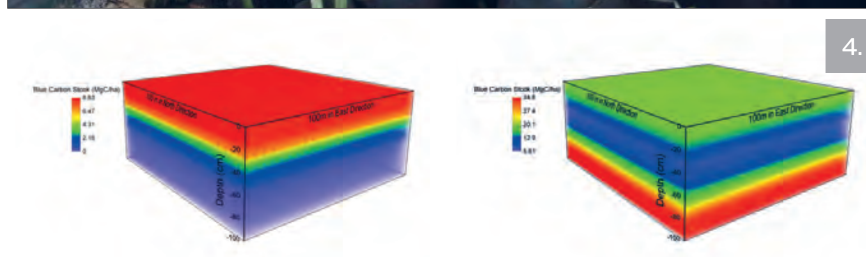
Participatory protocol for mangrove nursery management has been developed at Mandapam. The mangrove nursery (*Ceriops tagal*, *Rhizophora mucronata* and *Avcennia marina*) so initiated has been maintained for mangrove sapling planting in Thoppukadu mangrove area near Devipatinam in association with local fishers to protect coastal area, and to increase fish nursery grounds.

Two disaster management/ rescue groups (with motorized boats) in Thoppukadu village has been formed in participatory mode for rescue purpose during any natural calamities in this area.

Impact of climate extremes and disasters on ecosystem functioning with special emphasis on fisheries and mariculture

Research Project FEM/HBT/SUB/27

Three Dimensional Mapping of the Blue Carbon Stock of mangrove (*Avicennia officinalis*) stands at selected locations in Vembanad Lake was developed which can indicate how much carbon could be additionally stored in the mangrove sediments.



1&2. The plastic waste collected from Ward 9, Mulavukad Panchayat is being loaded for its transport to the recycling unit

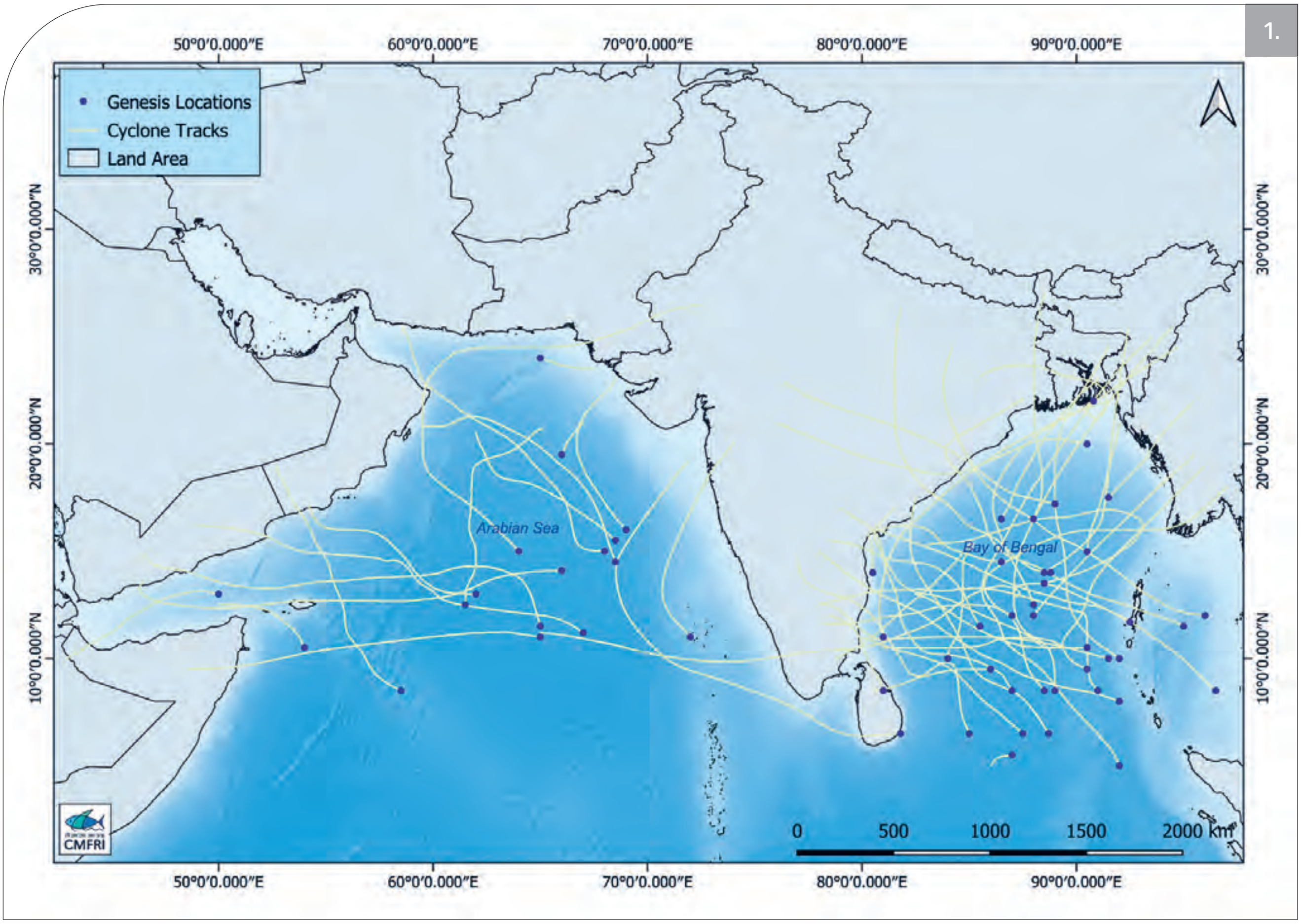
3. Mangrove nursery developed at Mandapam

4. Three Dimensional Mapping of the Blue Carbon Stock of selected mangrove stands

A Spatial Database and Animated Time Series Map of World Sardine Production for the Period 1956-2015 could be developed and uploaded in the Institute website (http://www.cmfri.org.in/infographics).

The genesis location and the track of cyclones occurred in the Arabian Sea and the Bay of Bengal during the period 1989-2018 was mapped. The total number of cyclonic systems formed in the Arabian Sea showed a positive trend and that in the Bay of Bengal showed a negative trend.

The cyclones had a significant negative impact on the marine both from the mechanized and non-mechanized sectors. However during the month



of cyclone Nilam in 2012, mechanized sector of the Nagapattinam district recorded an increased catch. This study pointed out that though the ecological system based changes were low due to tropical cyclone, the socio-economic impact was high and there is a need to develop early warning and vessel tracking systems to increase the preparedness of fishers to unexpected extreme events.

Abatement of coastal pollution through bioremediation

Research Project FEM/PLN/28

Seaweeds *Sargassum wightii* and *Kappaphycus alvarezii* were used for removal of copper and zinc from the effluent using biosorption. *Sargassum wightii* accumulated 17.6 mg/kg of zinc and 1.96 mg/kg of copper where as *Kappaphycus alvarezii* accumulated 76.06 mg/kg of zinc and 16.64 mg/kg of copper. Recovery of these heavy metals can be done by phytomining.

Live seaweeds and seagrasses are able to prevent the dissolution of shells of marine bivalves when treated with varying levels of CO_2. The remedial property of seaweeds is more effective (faster) at lower concentrations of dissolved CO_2. Experiments indicated that restoration of more habitats for seagrass and seaweed along the coastline and large scale mariculture of seaweeds is the immediate need to mitigate the adverse effects of ocean acidification more effectively.

The organic load from the fish processing industry were analysed for the bioactive compounds getting wasted with the effluent and can be a rich source of protein and lipid and can be extracted for better use.

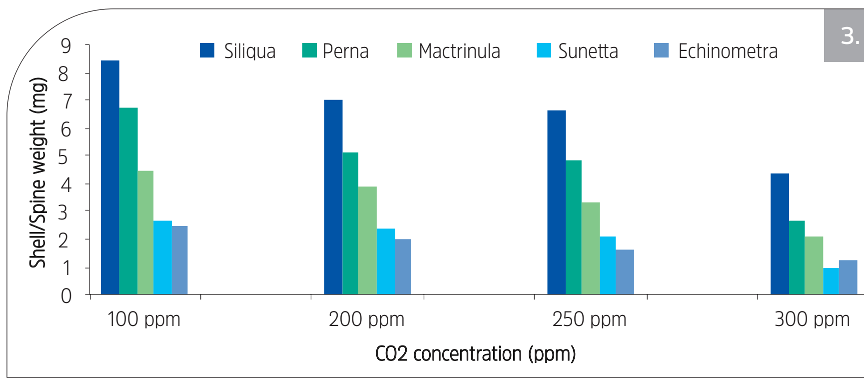
Bioremediation of the sewage was carried out with detritus degrading, euryhaline bacteria *Bacillus cereus,* the purple coloured photosynthetic bacteria (PPB) *Rhodobacter* sp. and mixed micro-algae (*Chlorella salina, Tetraselmis chuii, Isochrysis galbana* and *Thalassiosira sp*). and seaweed like *Ulva lactuca, Enteromorpha compressa and Stoechospermum marginatum.*

Ammonia level declined by 96.8% when treated with microalga *Pavlova*

1. The genesis location and the track of cyclones in Arabian sea and Bay of Bengal during 1989-2018
2. Experimental setup with waterhyacinth to treat cadmium effluent
3. Weight of shells saved by live seaweeds when treated with different levels of CO2
4. Cd content in bioremediated plants

2.

3.



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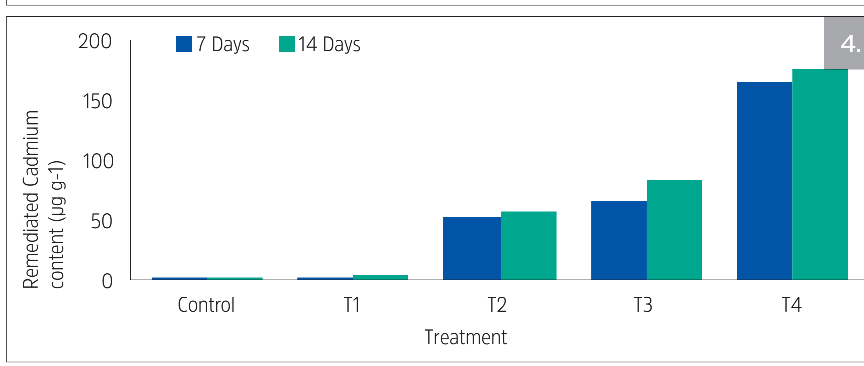
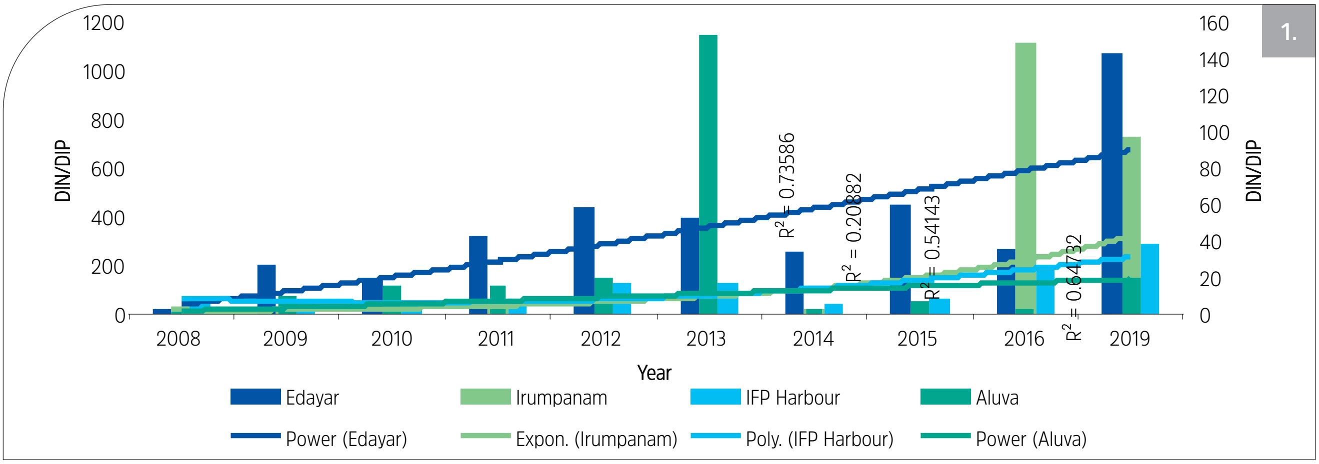


lutherii, 69.12% was noticed with *Enteromorpha compressa* and 60.29% with *Ulva lactuca.* Reduction in ammonia level enhances the nitrite and nitrate concentration in the bioremediation tank treated with green algae. In the treatment with the brown alga *Stoechospermum marginatum* nitrate was reduced by 83.6%. Bacteria also played a significant role in reducing ammonia, BOD and phosphate from the effluent.

Impact of heavy metals and ammonia toxicity on mangroves and other aquatic plants were studied and was established how the heavy metals thrown with industrial effluent in Kochi backwaters can damage these important biofence. It was also established the continuous flow of effluent in outfall area have made few sites as dead zone with zero DO and BOD.

Cadmium found in the cephalopod processing plant waste water was bioremediated using *Eichhornia crassipes* plants. The cadmium remediated plant was analysed for cadmium content using the



Inductively-Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Cadmium absorption efficacy of *Eichhornia* increased to an optimum level of Cd in effluents beyond which lead to root damage.

Assessment of coastal and marine pollution in selected maritime states of India

Research Project FEM/PLN/SUB/28

Pollution in coastal areas

On analysis of the seasonal variations in the beach litter constituents in central Kerala, a higher level of plastics contamination during monsoon was followed by pre-monsoon and post-monsoon. Estimated seasonal variation in micro and meso plastics contamination levels in the sediment of selected mangrove ecosystems in Ernakulam district, showed higher levels of microplastics. Stoichiometry of selected dissolved inorganic nutrient elements *viz.* nitrogen and phosphorus in the surface waters of selected locations of Vembanad Lake showed an increasing trend in the DIN/ DIP molar ratio which indicates P limitation and excess N in the selected sites.

Water quality grading carried out at four coastal stations of Mangalore area revealed "poor" grade of water quality conditions at all stations. Except for the months, July and December, in all other months the water quality factors were observed to have exceeded the permissible limit resulting in eutrophication at some of the stations in Gurupur estuary.

Plastic litter in beaches

Estimated the daily accumulation rate of marine litter on sandy beaches of Veraval coast, following the linear regression method, which showed an accumulation rate for 80 days was found 11.23 nos-1 km-1 day-1.

The linear regression model of plastic particles of three size classes from Gujarat coast beach sediments showed a higher correlation between micro and meso-plastic particles by number.

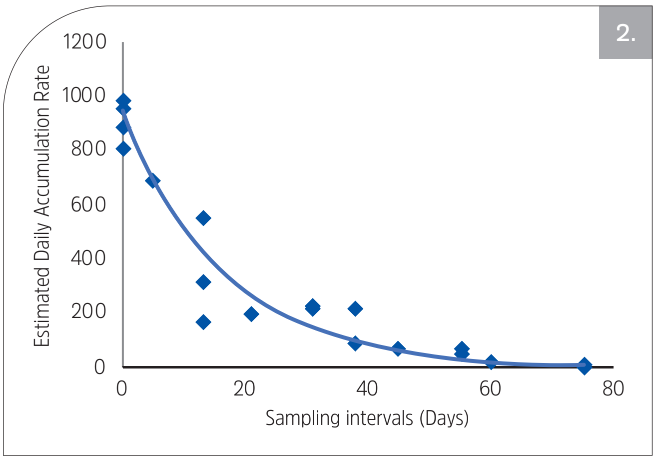
A survey conducted to assess the fishermen behaviour regarding marine litter management indicated varying responses. The fishermen primarily complained about the lack of proper disposal facility at harbour area which discourages them from bringing back the litters stranded in their net.

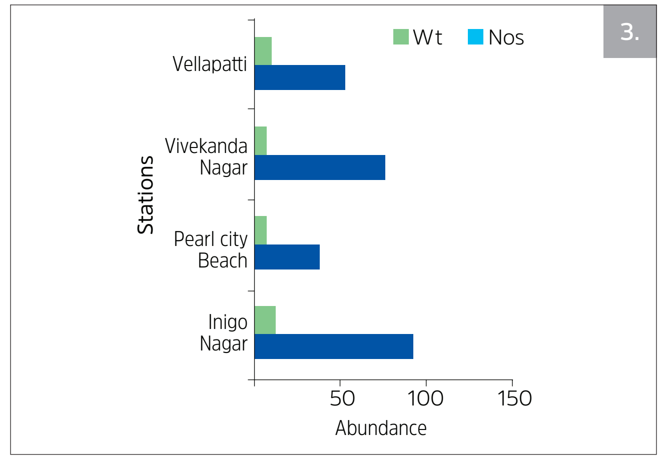
Plastic contamination levels within the top 2 cm sediments of four beaches in Thoothukudi revealed varying degree of fisher's interventions and cleaning measures by standard procedures. The mean density of total plastic litter contamination was higher in the beach sediments nearer to the fishing village.

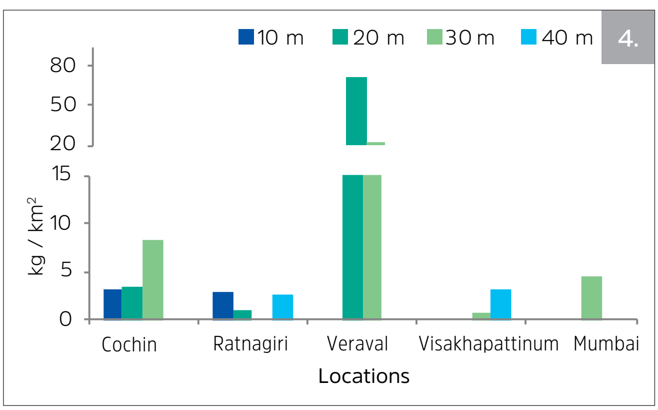
Compared to the 2013 survey, the study during 2019 indicated less degree of plastic litter contamination along the beaches of Thoothukudi, primarily due to the awareness created among the public. The dominance of mega-plastic (54%) was noticed only at beaches of recreational importance.

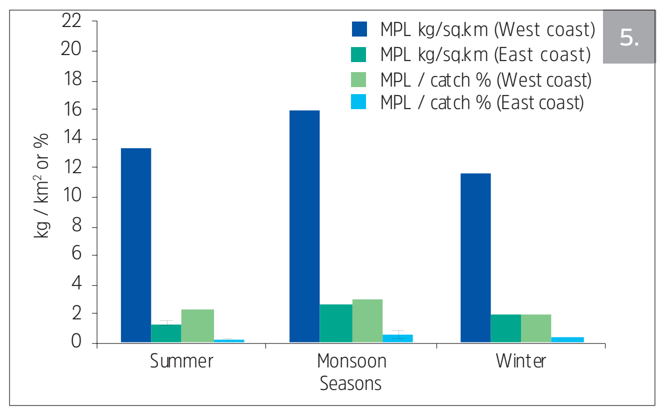
MPL from certain fishing grounds along Indian coasts

Spatial and temporal variations in the marine plastic litter (MPL) and its relative percentage in the quantity of fish caught from the trawling grounds off Cochin, Ratnagiri, Mumbai and Veraval along the west coast as well as Visakhapatnam from the east coast of India. The mean values of MPL from the fishing grounds









1. Variation in the annual mean molar ratio of DIN:DIP in Vembanad Lake
2. Accumulation rate of marine litter on sandy beaches of Veraval coast
3. Mean values of total plastic contamination in the sediments of beaches of Thoothukudi
4. Marine plastic litter recorded from 5 fishing grounds along east and west coast of India
5. Seasonal account of MPL in fishing grounds

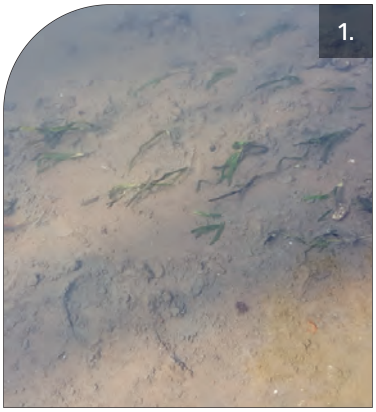
registered the maximum of 55.2 kg/km^2 off Veraval and the lowest value of 2.03 kg/km^2 off Visakhapatnam, registering a national average of 13.82 kg/km^2. The relative percentage of MPL over the fish catch remained highest (3.8%) at Veraval and lowest from Visakhapatnam (0.33%) with the national average of 1.94. Monsoon season registered maximum MPL in the fishing grounds of all the coastal regions studied.

Considerable reduction in beach sampling areas for litter assessment could be noticed along Mandapam-Rameswaram coast, over the previous years due to severe coastal erosion

Marine Macrophytes in India-Resources dynamics & Ecosystem services

Research Project FEM/MPH/29

One of the major threats faced by the seagrass *Halophila beccarii* bed observed in Kadalundi estuary is the sand bar formation near to the bar mouth and its further extension to the seagrass bed and the habitat degradation. *Halophila beccarii* (commonly called as Beccari's Seagrass) is one of the smallest seagrass found in Kadalundy mangrove area, Calicut. It is listed as 'Critically Endangered' on the IUCN Red List. Faunal association include gastropods namely *Tibia,*



1. Underwater photograph of seagrass transplanted site.
2. Lighthouse lizard fish Synodus jaculum observed from seagrass bed

Murex, Trochus besides several coastal birds and fishes.

Production of red seaweed *Kappaphycus alavarezii* through mariculture along south east coast of India ranges from 350 to 1250 tonnes dry weight. Production of seaweeds for agar and align extraction through exploitation from the south east coast of India during the reporting period was determined as 3540 tonnes dry weight (1,700 tonnes of *Saragassum* spp., 120 tonnes of *Turbinaria* spp., 550 tonnes of *Gracillaria edulis,*1,000 tonnes of *Gracillaria salicornia* and 170 tonnes of *Gelidiella acerosa*). Seagrass transplantation experimental study was conducted at Panaikulam and Maunaikadu coasts. PVC rafts of 1x1m size were constructed and seagrass species *Cymodocea serrulata* and *Syringodium isoetifolium* were installed in jute threads at 10 cm interspace over sandy areas in the identified areas. Seagrass canopy structure, sediment organic carbon, Seagrass leaf chlorophyll were carried out periodically in Chinnapalam, Sethukarai, Devipatinam and Thirupalaikudi. The organic carbon content of sediments from Chilka Lake ranged from 0.245% to 0.9287% depending on the density of macrophytes in the meadows studied. The OC content at the top layer (0-15 cm) was more than the bottom layer (15 -30 cm) indicating the blue carbon in top crest of sediment.

Seagrass flora of Lakshadweep archipelago consists of 8 species from 5 genera and all the atolls harbour seagrass species and grow as meadows except in Bitra. From Veraval coast the survey for marine macrophytes was conducted along Bhurai Reef and Sikka reef of Gulf of Kutch and four species of seagrass namely *Halodule uninervis, Halophila ovalis* and *Halophila beccarii* was observed in the survey regions. Areas without seagrass included Bet Dwarka, Khara, Okha village. Foraging of huge quantities of shoots of seagrass *Cymodocea serrulata* that were seen lodged near the beaches of Devipattinam and Thirupalaikudi by herd of goats is one of the ecosystem services of *Cymodoceaa* meadows.

The project team contributed inputs for the document prepared by TIFAC, DST New Delhi for formulating an effective strategy and policy recommendations for sustainable utilization of seaweed resources. Two awareness programmes were conducted at Chinnapalem and Soliakudi to create knowledge among the local fisher folks, their family members including their school going wards on the importance of seagrass meadows for their livelihood support and the need to conserve them to increase the fish wealth in the region. Two programmes conducted at Chinnapalem and at Soliakudi.

Blue carbon stock of Gulf of Mannar and the Palk Bay were computed from the organic carbon content and dry bulk densities of sediment core taken from the meadows. The soil carbon density of both Gulf of Mannar as well as that of Palk Bay were higher in subsurface cores and the blue carbon stock of seagrass meadows of Gulf of Mannar was estimated to 0.00177 Tg and that of Palk Bay was 0.04395 Tg. The blue carbon stored in seagrass meadows of Gulf of Mannar is valued for 17707 US$ and that of Palk Bay for 439453US$. Lighthouse lizardfish *Synodus jaculum,* (Russell and Cressey), 1979 observed from seagrass beds adjoining Sethukarai has been a new record to Gulf of Mannar.

Climate Change

Research Project: CFD/NEC/05

National Wetland Information, Mobile Application & Website developed in collaboration with Space Application Center (SAC-ISRO) through NICRA project

1. Multi-dimensional scaling ordination for prey dissimilarity between seasons
2. Yearly distribution of chlorophyll in four coastal regions and three seasons

Phenology and Distribution

Ontogenetic and seasonal variations of smooth blaasop, *Lagocephalus inermis*

Trophic studies with focus on ontogenetic and seasonal variations were carried out on *smooth blassop Lagocephalus inermis* from south eastern Arabian Sea, which indicates *L. inermis* as a benthic predator feeding mainly on cephalopods (IRI % 53) followed by crustaceans (35 %) and fishes (12 %). Seasonal analysis of diet using cluster analysis showed that maximum similarity was between pre-monsoon and post-monsoon to which monsoon got linked. SIMPER analysis showed that major prey items contributing to the dissimilarity between pre-monsoon, post-monsoon and monsoon was *Saurida* spp. and crabs, while prawn and *Apogon* spp. contributed to the dissimilarity between monsoon and post-monsoon. There is shift in diet to teleost in the adult stages and occupies one of the highest trophic level in the ecosystem.

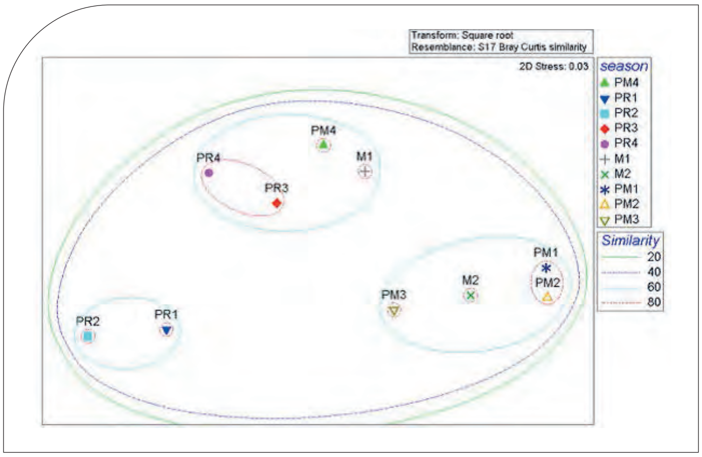
Body size-dependent response and feeding habits of sardine and mackerel along southwest coast of India

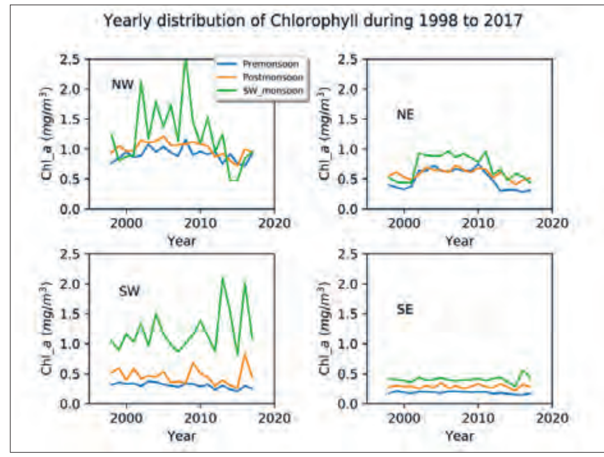
Multiple correlation analysis and linear regression models indicates significant change in mean length of Indian mackerel (*Rastrelliger kanagurta*) and Indian oil sardine (*Sardinella longiceps*) corresponding to SST (1960-2016) and SSC (1998-2016), with the effect being highest for the pre-monsoon (February-May) SST ($p<0.001$) and post-monsoon (October to January) SSC ($p<0.001$). The response of SBIs in terms of extreme SST during the summer and low SSC during the post-monsoon implies the biological or distributional sensitivity of these pelagic fishes to changing marine climate. The results also reveal that the size structure of the selected fishes has changed over time, and the decrease in the relative abundance of larger fishes has occurred over a long period of time.

Trophic level indices and Amundsen plot exposed the ontogenetic variation in the diet composition whereas CLUSTER analysis revealed the seasonal diet patterns of *Sardinella longiceps*, which indicates that the occurrence of prey items in the diet of fish has strong relationship with the climatic variables (SST, Pr, SSS, Chl *a* and CUI). GAM model revealed that occurrence of prey items in the diet of Indian mackerel were also influenced by environmental variables. An increase in the relative importance of dinoflagellates, *Acetes* and *tintinnids* in the diet over the historic period was observed. Shift in the diet composition of younger fishes were also observed.

Population genomic structure analysis of Indian oil sardine

The population of *Sardinella longiceps* from Oman Sea and NAS shows a reduced level of genetic diversity when compared to other populations. The pairwise comparison of genetic differentiation (FST and RST) indicates that the Oman sea population was highly differentiated from all other populations, with very high significance. The frequency distribution of FIS values across loci within each population indicates that SEAS has a fraction of loci with FIS value > 0. The loci identified as outliers (FIS> 0) may be the representation of genomic regions of local adaptation, isolated genomic regions of divergence with gene flow and genomic regions of speciation in *S. longiceps*. These signals of cryptic structuring/ assortative mating can be further investigated to identify the genomic region of genetic divergence in *S. longiceps* and *clupeoids*.





Climate change modeling

Influence of oceanographic drivers on small pelagic fishery

Path analysis reveals that the significance of influence of causally dependent oceanographic variables on the CPUE of Indian oil sardine is in the order SSC > SSS > Pr for southeast coast. It was found that, major small pelagic fishery along the southwest coast rely on the seasonally occurring upwelling and downwelling phenomena as well as the coupled ocean-atmosphere dynamics.

Spatio-temporal variations of chlorophyll concentration along Indian coastal zones

Analysis of satellite data (1998–2017) reveals seasonal and regional variations in chlorophyll distribution, with increasing trend in pre monsoon season for all coastal regions during the first decade, whereas a decreasing trend was noticed in the second decade.

Monsoon season of Northwest zone exhibited maximum and minimum anomaly values during the second decade. Cumulative trend of two decades reveals that the southeast zone exhibited increasing chlorophyll trend in monsoon season, while other zones exhibited decreasing trend in all seasons.

Fishery and gear vulnerability to climate change

Among the four maritime regions, the fishery along the southeast coast as well as northeast coast were found to be highly vulnerable with a relative vulnerability score of 1.80 and 1.69 respectively, whereas the fishery along northwest and southwest coasts was found to be moderately vulnerable to climate change impacts with a score of 1.26 and 1.34 respectively. Among the harvest methods across all the regions, mechanized sector recorded highest vulnerability score in relation to climate change. The predicted changes in the vulnerability of the fishery and harvest methods under various RCP scenarios reveals that both the gear vulnerability and fishery vulnerability across the regions increase under the current harvesting strategies.

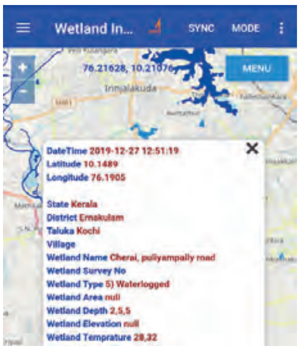
Climate resilient technologies

Mobile application and website for regional wetland assessment and advisories

The wetland mobile application and associated website with access to scientific communities as per the project requirement has been developed and transferred along with the operational manual by Space Applications Centre (SAC)–ISRO on September 30th 2019. The app and portal could enable integration of field level datasets of wetlands to the existing wetland database of SAC-ISRO, so as to enable regional wetland advisories and impact forecast.

NICRA project of ICAR-CMFRI is entrusted as the national level admin for coastal wetlands and further scientific stakeholders shall be identified through the project. The android mobile application was used in field sampling for around 30 wetlands of Ernakulam district including 20 from coastal regions, 5 from flood affected areas and 5 facing saline water intrusions. The field data (Real-time wetland image, pH, water temperature, air

1. Transfer of user manual of e-platform by SAC–ISRO scientist



temperature, salinity, humidity, turbidity, colour, nearby vegetation, pollution sources) and lab analysed data (DO, ammonia, phosphate and silicate) of the sampled wetland were integrated to the geospatial platform.

To maintain data quality, the user fed information need to be approved by an associated expert and further by the admin, so as to visualize in the common portal. Once visualized, a click on the wetland point source in the spatial map displays input information on real time water and sediment quality, species health and climatic threats.

Climate Smart Village (CSV) development

Vulnerability assessment of coastal villages

Assessment of twenty one coastal villages, grouped into three clusters of Thiruvallur district in north Tamil Nadu, points out that socio-economic development is directly impacted by loss of livelihood and sustenance sources, while low education and employment opportunities could be attributed as the indirect impacts. 81% of responds ranked habitat destruction and 79% ranked decline in fish availability as major factors of immediate concern, while 64% ranked lack of development programs as a cause for concern. Natural calamities and climate change were ranked by 61% and 53% of the respondents as major issues. Karunkali village was found to be most vulnerable, followed by Korai kuppam, Ernavur kuppam and Kattupalli kuppam. Vairavan kuppam, Lighthouse kuppam and Goonan kuppam were the least vulnerable. The overall vulnerability index for coastal Thiruvallur was obtained as 0.701, indicating high vulnerability. The major issues to be addressed are interventions for protection and restoration of coastal water habitats, reducing pollution in coastal waters, improving infrastructure facilities for social development and living standards, and, awareness generation drives among the coastal communities for effective participation in working towards these goals.

Climate Clubs as a socio-economic and ecological resilient strategy

A first of its kind network of climate clubs for enhancing coastal resilience is envisaged and is being processed for registration in the name of 'CMFRI Climate Club Network'. The intervention could bring the climate change stakeholders in a common platform across coastal states, so as to widen the effective reach of the technology demonstrations such as open sea cage culture, IMTA, seaweed farming, climate resilient products, e-commerce and climate resilient village development. The multi-tier interactions ensure community participations in conservation of coastal ecosystems such as wetlands and mangrove ecosystems. Besides, the club could play key role in reporting the regional climatic adversities, impacts and vulnerabilities so that it could be assessed and intervened by scientific communities, administrative bodies or policy makers. Goals of Greenhouse Gas emission reduction and nationally determined contributions (NDCs) as per International climatic agreements could be better implemented, if semi-formal organization like clubs with balanced representation of coastal community and scientific stakeholder could be evolved.

Economic Sustainability and Trade

Research Projects SEE/SOC/33 and SEE/DCD/35

Valuation of marine fish landings, economic performance and supply chain management

Valuation of marine fish landings

The provisional estimate of the value of marine fish landings during 2019 at landing centre level was ₹60,881 crores, (15.03% increase over 2018). The unit price per kg of fish at landing centre was ₹170.24, (11.33 % increase over 2018). At the retail level, the estimated value was ₹92356 crores (14.33 % increase over 2018). The unit price at the retail market level was ₹258.26 (20.88 % increase over 2018). The marketing efficiency determining the producer's share of the consumers rupee was found to be 65.90 (0.61 % increase over 2018).

State-wise valuation across the value chains

Across the maritime States, Gujarat recorded the highest realization of prices at the landing centre and retail centres sharing 20.54 % and 20.98 % of the value realized at landing and retail centre levels respectively followed by Kerala (20.35% and 18.97%) and Tamil Nadu (16.51% and 18.08%).

Species-wise valuation of marine fisheries in India

Out of the total marine fish landings, ribbon fishes accounted for the highest share of 6.13 % but in value terms accounted for 5.40 % at landing centre level and 4.84 % at retail centre level. Penaeid shrimp accounted for the maximum share in valuation at both landing centre level (13.49%) and retail centre level (12.43%).

Macroeconomic indicators in marine fisheries sector

At the national level (macro level) the total operating cost was estimated at ₹34,702.24 crores and the net operating income at ₹261,78.89 crores. The average capital productivity worked out to 0.57 and the gross value added to the marine fisheries sector was estimated at ₹40,790.36 crores, which is 67 % of the gross revenue.

Economic performance of marine fishing methods

The economic performance of the various fishing methods in selected centres across the States was assessed using major economic indicators namely net operating income, operating ratio (capital productivity), labour productivity, input-output ratio and gross value added.

It is seen from the Table that the capital productivity sector was most efficient in multiday-day gill net at Chennai (among mechanized units) with the lowest operating ratio of 0.46 followed by multi-day trawling at Kakinada (0.57) and single day fish trawl (0.55). Over all the capital productivity was very much efficient in case of non-mechanized bottom set gillnet (0.42). This is due to the less proportion of crew wages as most of the non-mechanized units are operated by family labour only.

Valuation of marine fish landings 2015-19

Parameters	2015	2016	2017	2018	2019
Valuation at landing centre level ('000 crores)	40.10	48.38	52.43	52.63	60.88
Valuation at retail centre level ('000 crores)	65.18	73.29	78.40	80.32	92.36
Fishermen Share of Consumers Rupee (%)	61.52	66.01	66.87	65.53	65.90

Valuation of marine fish landings across the States 2019

State	Landing centre valuation (LCV) (₹crores)			Retail Centre valuation (RCV) (₹crores)		
	2018	2019	Share (%)	2018	2019	Share (%)
Andhra Pradesh	2,662	3,341	5.49	4,159	5,480	5.93
Goa	920	601	0.99	1,312	874	0.95
Gujarat	11,536	12,568	20.64	17,382	19,379	20.98
Karnataka	6,442	7,118	11.69	10,470	10,030	10.86
Kerala	10,827	12,387	20.35	14,969	17,515	18.97
Maharashtra	5,771	6,402	10.52	8,510	9,835	10.65
Odisha	1,255	1,563	2.57	2,159	2,526	2.73
Puducherry	733	832	1.37	1,050	1,265	1.37
Tamil Nadu	8,576	10,054	16.51	14,464	16,695	18.08
West Bengal	2,759	4,306	7.07	4,184	6,370	6.9
Daman Diu	1,156	1,709	2.81	1,664	2,386	2.58
Total	52,637	60,881	100.00	80,323	92,356	100.00

Species wise share in landings and valuation (in per cent)

Species	Landings (t)	Share (%)	LCV* (crores)	Share (%)	RCV* (crores)	Share (%)
Indian mackerel	166124	4.65	3183	5.17	4605	5.08
Ribbon fishes	219165	6.13	3324	5.40	4394	4.84
Non-penaeid shrimp	180103	5.04	4270	6.93	6617	7.30
Penaeid shrimp	194650	5.44	8311	13.49	11272	12.43
Threadfin breams	9078	0.25	2442	3.96	3566	3.93
Other sardines	170899	4.78	1854	3.01	2993	3.30
Oil sardine	145292	4.06	1469	2.38	2529	2.78
Other perches	95720	2.68	1640	2.66	2538	2.80

*LCV-Landing centre value: RCV-Retail centre value

Marine fisheries in Indian economy: Macro-economic indicators 2019

Sl.No.	Macroeconomic Indicators	Value (₹crores)
1	Value at landing centre (₹crores)	60881.13
2	Total operating cost (₹crores):	34702.24
3	Net operating income: (₹crores)	26178.89
4	Average Capital Productivity	0.57
5	Gross Value Added (GVA)	40790.36
6	GVA as a percentage of Gross revenue	67.00

Economic performance of fishing methods at selected Centres, 2019

Sl.No.	Centre	Craft-gear combinations	Capital productivity
1	Chennai	Multi-day trawling (4-5days)	0.67
		Multi-day gill net (2-5 days)	0.46
2	Kakinada (Andhra Pradesh)	Multi-day trawling (4-5days)	0.57
3	Visakhapatnam (Andhra Pradesh)	Multi-day trawling (4-5days)	0.63
4	Thiruvananthapuram (Kerala)	Shore-seine	0.72
5	Kollam (Kerala)	Single-day trawling	0.43
6	Kollam (Kerala)	Multi-day trawling	0.86
7	Mangalore (Karnataka)	Multi-day trawling	0.57

Andhra Pradesh and Odisha

Economic analysis of motorized boats in Andhra Pradesh and Odisha showed that the average operating cost per trip was ₹2,856 to ₹8,975. Fifty % of net revenue was paid as crew share after deducting the operating costs from the gross revenue. Wages for crew and expenses on diesel accounted 95 % of the total operating cost. The labor productivity worked out to 3.58 to 19.50 kg/ crew / trip.

In the non-mechanized sector, in Andhra Pradesh and Odisha, it was observed that among the three gears operated (Hook & Line, *Naravala* and Bottom Set Gillnet), the capital productivity was highest in hook and line in Andhra Pradesh at 0.5. The gross value added was highest at ₹7,887 in case of hook and line in Odisha and the gross added value (GVA) as a % of gross revenue was highest at 100 % in case of hook and line fishing in Andhra Pradesh. The increased cost of fishing per trip and the reduced catch have become important constraints affecting the economic returns

Tamil Nadu

In Tamil Nadu, the analysis of economic performance of fishing methods across the selected centres indicated that the capital productivity was most efficient in non-mechanized bottom set gill net in Ramanathapuram at 0.42 (lowest operating ratio) and the minimum in multi-day trawling at Thuthoor and mechanized gill net in Mutttom both with the capital productivity of 0.78 (highest operating ratio).

Karnataka

The analysis of economic performance of fishing methods across the selected centres in Karnataka indicated that the capital productivity was more efficient in multi-day purse seining (0.42) than multi-day trawling (0.57) in Mangalore. However, the GVA was higher in multi-day trawling (₹2,36,244) than multi-day purse seining (₹2,22,328).

Kerala

The analysis of the economic performance of fishing methods in Kerala revealed that the capital productivity was almost above 0.70 indicating higher operating cost across all the craft-gear combinations.

This emphasizes the need for optimization of resource uses especially fuel and crew wages, which are the significant inputs in the fishing operations. The gross value added (GVA) was highest in multi-day trawl (4-5 days) at Kollam at ₹2,52,203 followed by boat seine in Poovar (₹39,760)

West Bengal

The economic performance of fishing methods Purba Medinapur (West Bengal) was assessed. The average operating cost per trip of multi-day (>6 days) in West Bengal worked out to ₹339223 for MDT (<6days) at₹273246. The operating cost is 20 % higher in MDT (>6 days) than MDT (> 6 days). The net profit is 2.5 % higher in MDT (> 6 days) than MDT (<6 days).

Economics of Artisanal Offshore Vessels (AOSF)

Policy Imperatives for Promoting Value Chains of Agricultural Commodities in India (Network project with National Institute of Agricultural Economics and Policy Research (NIAP)

An economic analysis of fishing and value chains of the deep-sea fishing

Economic performance of fishing methods in Andhra Pradesh and Odisha, 2019

	Capital Productivity	Labour Productivity	Input-Output Ratio	Gross Value Added (₹)	GVA to Gross Returns (%)
Mechanized: Kakinada (Andhra Pradesh)	0.63	321	0.58	1,63,052	41.56
Visakhapatnam (Andhra Pradesh)	0.51	386.4	0.42	2,65,801	57.72
Motorized: Chintapalli ((Andhra Pradesh))	0.59	3.58	0.17	4022	82.27
Bandarvani Peta (Andhra Pradesh)	0.57	9.05	0.14	5998	86.18
Gopalpur (Odisha)	0.59	4.47	0.19	7767	81.25
Puri (Odisha)	0.56	19.5	0.12	14086	87.94

Economics of fishing methods in Kerala

Centre and sector	Capital Productivity	Labour Productivity	Input-Output Ratio	Gross Value Added (₹)	GVA to Gross Returns (%)
Shore seine - Poovar	0.72	5.06	0.29	4,850	74.6
Boat Seine - Poovar	0.83	28.98	0.27	39,670	84.3
Hook and line - Poovar	0.86	20.75	0.60	6,314	51.5
Thangal Vallam (2 days) - Poovar	0.94	17.01	0.81	21,953	51.3
Multi-Day Trawl (4-5 days) - Kollam	0.86	389	0.66	2,52,203	57.6
Hook and line (motorised) - Kollam	0.84	27	0.39	19,760	82.3

industry based at Thoothoor, Tamil Nadu was carried out based on primary surveys conducted during 2018-19 to understand the existing cost and returns associated with deep sea fishing, its various value chain linkages and measures for future development.

The techno-economic features of artisanal offshore fishing (AOSF) vessels are presented, which operated from Thengapattanam fishing harbor, Thoothoor, and Cochin Fisheries Harbor (CFH), Kochi based on data pertaining to 515 fishing trips made by 50 sample vessels. About 66 % of the respondents owned the AOSF Vessels. Fuel (33% of the total operating cost) and crew wage (31%) shared the maximum proportion of the operating for AOSF vessels. Comparative estimates with other artisanal fishing methods along the south west coast of India show that, average income realized by vessel crew per working day for AOSF was around ₹568 whereas that for inboard ring seine vessels and purse seine vessels were ₹1,305 and ₹1,643 respectively. The comparatively lower economic performance of the AOSF vessels at Thuthoor can be due to (i) relatively high costs incurred per fishing trip that lasts for 20-30 days covering a total distance of 1000-1500 nautical miles (NM) (ii) lower fishing efficiency due to manual gear operation (iii) limited fish hold capacity owing to lower size of vessels (iv) the need to carry ice throughout the trip due to lack of slurry ice making/ freezing equipment onboard, that also contributes to lower fuel efficiency (v) lack of on-board fish handling skills of the crew resulting in greater spoilage and in turn, lower price for the produce (vi) under pricing of landed fish due to collusion between middlemen and exporters' agents at landing centres and (vii) high dependence of fishers on informal financial agents for credit that adds to the cost in the form of interest payments.

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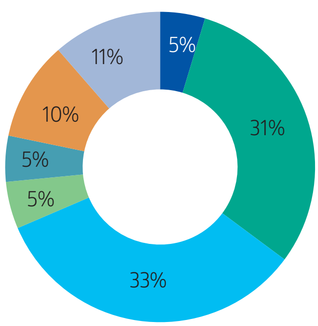


Technical profile of the artisanal offshore vessels, 2018

Technical features	Values
Length of vessel (m)	17.1
Width of vessel (m)	5.6
Horse power range (HP)	110-190
Main gears used	Hook & line, gillnet, long line
Total capital expenditure (₹, million)	4.255
Main resources targeted	Deep sea shark, tuna, squids, seer fish, bill fishes, rays
Fish hold capacity (tonnes)	16.0
Crew size (number)	12
Length of long line (m)	7,400-55,000
Length of gillnet (m)	7,400-46,300
Number of trips per year	11
Number of days per trip	23
Fuel consumption per trip (litres)	2,240
Duration of voyage per trip	216
Actual fishing hours per trip (hours)	336
Duration of hauling (hours)	8-16
Depth of operation (range in m)	150-2000

Price behavior of marine fish varieties

The price behaviour of the marine fish varieties across the landing centre and the retail center is indicated below

Average landing centre price realization

There is a wide variation in landing centre prices across species. The landing centre price ranged from ₹75.76/kg for oil sardines to ₹386.58/kg for Penaeid shrimps, closely followed by squid at ₹188.87/kg.

The price ranges of major fish species across the coastal states of India is presented in Table below.

Average retail centre price realization

The analysis of retail price behaviour of major species in India indicated that Penaeid prawns realized the highest retail at ₹440.66 followed by Non-Penaeid prawns (₹321.26), while oil sardines realized prices at ₹130.57 per kg which is the lowest.

The Table below shows the price ranges of major fish species across the coastal states of India.

Marine fish market efficiency

Across states

Marketing efficiency refers to the fishermen share of the consumer's rupee (FSCR) across the major species. The marine fish marketing efficiency across the different states in India indicated that Daman Diu registered the highest (71.64 %), followed by Karnataka (70.97 %) and Kerala (70.72 %).

Across species

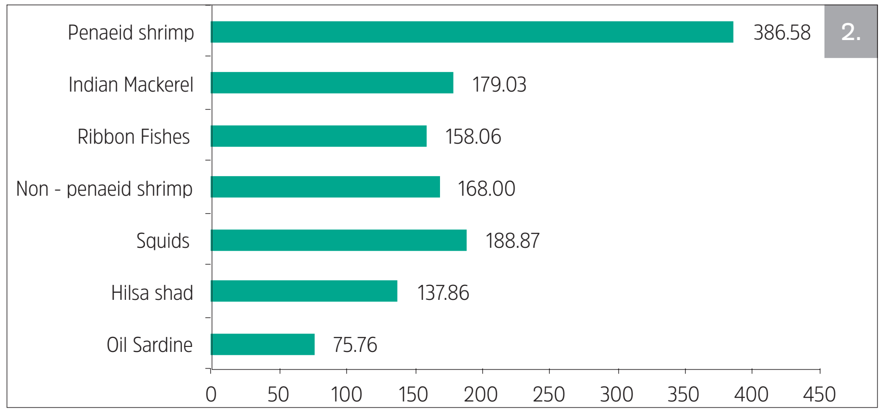
The marketing efficiency across the major species based on the level of marketing efficiency is given below.

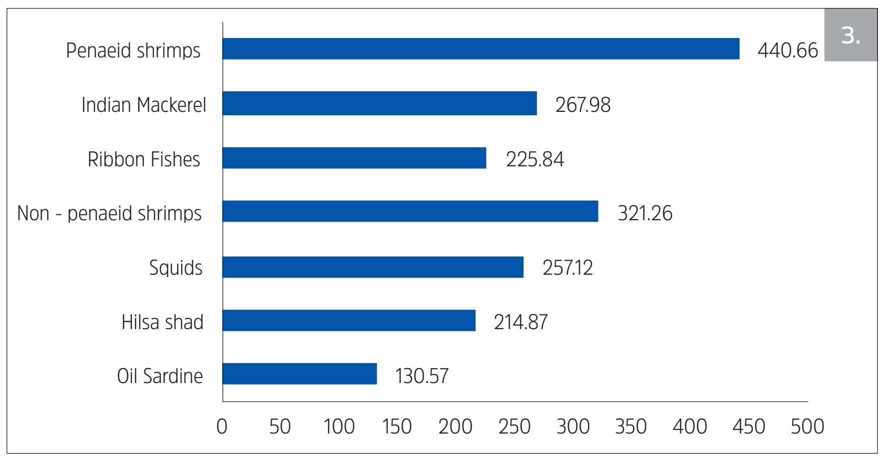
In general the high value species like penaeid shrimps (79%), stolephorous(72.66%), squids (72.60%) and cuttlefish (72.26%) registered higher marketing efficiencies compared to non-penaeid shrimps, threadfins, lizardfishes, snappers, scads and oil sardines.

Assessing fish consumption paradigms and spatial demand across India

The trends and patterns of fish consumption as well as the factors that

1. Operating costs of AOSF vessels, 2018-19
2. Average landing Centre Price realization – All India (₹kg)
3. Average Retail Centre Price realization – All India (₹/kg)





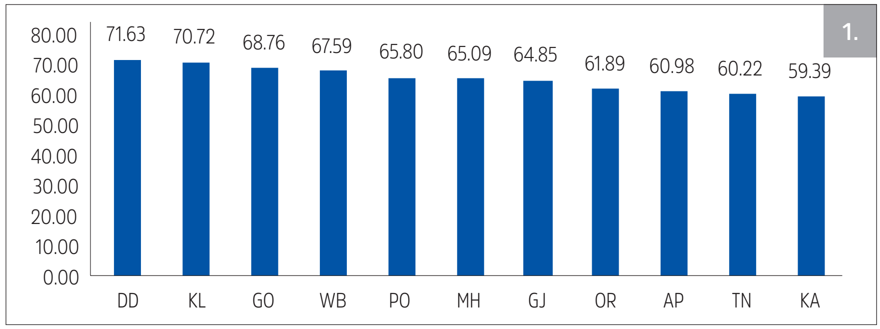
State-wise price behaviour of landing centre prices of major species 2019

Species	WB	OR	AP	TN	PO	KL	KA	GO	MH	GJ	DD
Oil sardine	68.15	65.62	55.16	90.88	55.18	138.9	106.9	82.88	113.2	56.5	NA
Hilsa shad	348.3	121.2	126.2	80.1	80.1	NA	NA	285	115.6	181.6	178.2
Ribbon fishes	114.6	106.9	144.5	109.8	128.9	229.4	185.7	204	215	148.5	151.5
Penaeid shrimp	424.6	242.2	299.1	319.9	287.5	972	320.7	413.4	394.8	319.8	258.6
Non-penaeid shrimp	168.1	126	167	127.6	NA	265	NA	185	246.4	185.3	209.7
Squids	172.7	167.7	197.2	175.8	140.5	234.3	200.4	230	223.7	170.5	165
Indian mackerel	132.9	142	136.8	165.4	193.8	245.2	218.7	183.2	200	169.3	182

NA Due to no landings/trade WB- West Bengal ,OR- Orissa ,AP- Andhra Pradesh , TN- Tamil Nadu , PO- Puducherry , KL- Kerala, KA- Karnataka, Go- Goa, MH- Maharashtra, GJ- Gujarat, DD- Daman & Diu

State-wise price behaviour of retail centre prices of major species 2019

Species	WB	OR	AP	TN	PO	KL	KA	GO	MH	GJ	DD
Oil sardine	115.0	105.4	96.04	150.2	91.92	244.45	185.65	123.75	211.23	112.53	NA
Hilda shad	460.7	237	237.3	160.3	131.0	NA	NA	385	213.07	270.03	268.93
Ribbon fishes	177.3	144.0	223.1	140.7	164.0	339.08	285.65	315.11	315.52	177.48	201.96
Penaeid shrimp	526.6	358.5	334.3	279.8	320.5	1154.6	382.52	225.33	564.71	285.58	294.57
Non-Penaeid shrimp	268.8	232.4	243.2	427.7	366.2	386.25	NA	545.55	365.96	376.53	321.05
Squids	262.5	234.5	278.6	265.3	184.1	318.74	244.47	281.15	332.55	220.15	205.99
Indian mackerel	203.41	205.43	188.34	287.59	249.3	300.15	328.53	283.43	310.56	303.57	287.47



drives people to consume fish across 1,440 respondents from four districts of Kerala covering coastal – non coastal and urban–rural locale namely urban coastal (Thiruvanandapuram), rural coastal (Alappuzha) and non coastal urban (Kottayam) and non coastal rural (Palakkad) districts were analysed. The analysis revealed that average monthly consumption of the fish among the respondents was found to be 1.5 – 2 kg. Conjoint analysis results indicates that the optimum fish quality set, which provides the consumers with optimum benefit is the variety of fish from the retail fish markets which are highly fresh and good quality. The preference assessment index of the study point outs Sardine remains the most preferred fish with a high score of 0.58 followed by Mackerel (0.56),tuna (0.59), shrimp (0.54), stolephorous (0.53), pomfret (0.51), solefish (0.51), seer fish (0.49), threadfinbreams(0.489 and crab (0.41). Across the income groups there exists a high uniformity between the respondents in buying mackerel as well as sardine. The discriminant function analysis indicates that quality is the most significant discriminating factor with highest Wilks' Lambda of 0.998 and highest canonical loading (0.795 or79.5 %) describing the major driver of fish consumption preferences of the consumer followed by nutrition (0.556 or 55.6 %) and availability (0.532 or 53.2 %). The unavailability of the fish species and irregular supply were indicated as the major constraints of fish consumption. The study also advocates the need for with strict quality control measures from Government authorities for enhancing the fish consumption.

2020 and beyond - strategies for augmenting sea food revenue

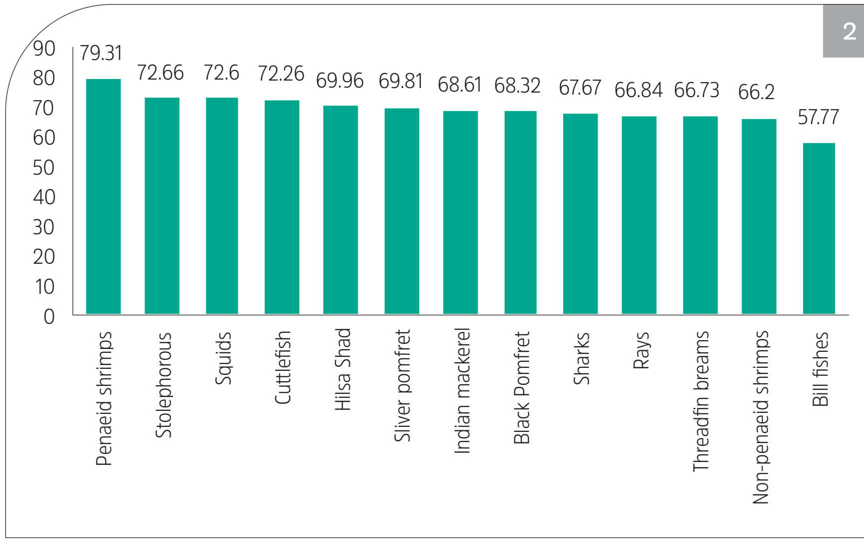
Strategies for augmenting sea food revenue were scrutinized by analyzing the measures for enhancing the value addition of the Indian marine fisheries sector. The export performance of the marine sector, scenario of the sea food export, consumer preferences, value addition and measures for enhancing value addition technologies were major concern of the study. The results showed that exports to various geographical destinations have increased almost three-fold during the post-recession period that the pre-recession period.

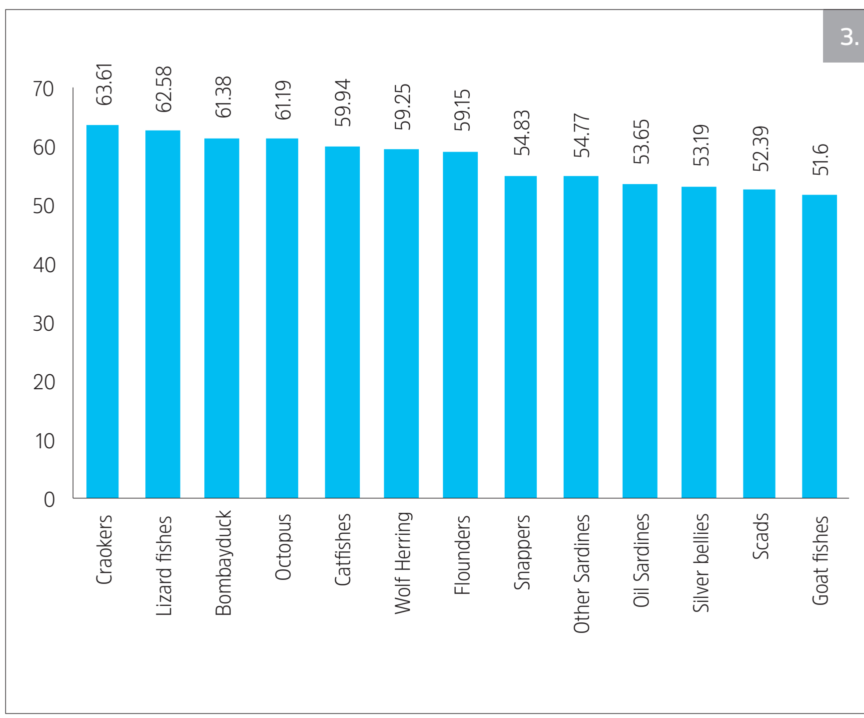
Commodity wise trend assessed using Simpson index of diversity (SID) indicated that frozen shrimp (0.56 to 0.95) holds the first place in the complete diversification of Indian export during the pre-post-recession periods followed by frozen squid (0.88 to 0.93) and frozen cuttle fish (0.88 to 0.89), whereas for frozen fin fish SID have decreased to almost half during the post-recession period. The value added products have strengthen the Indian fisheries export by contributing a major share in the fish export over the years from 2014-18.

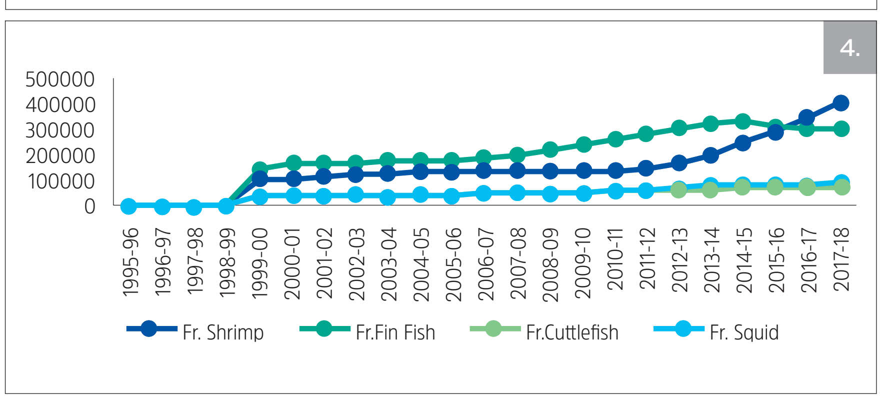
The share of value added products have consistently increased from 2.64 percent to 6.31 percent to the total fish exports from India. The export of raw materials from India have considerably increased and crustaceans, molluscs and other aquatic invertebrates, prepared or preserved (excluding smoked) (code 1605) and prepared or preserved fish; caviar and caviar substitutes prepared from fish eggs (code 1604) tops the major value added products exported from India.

US remained as the major source importing market of Indian export. The results point outs the need for strengthening the value addition processes and the identification of more innovative technologies to improve the value addition of sausages, prepared or preserved meat, extract of juices of meat. Fish, molluscs, crustaceans

1. Average Market efficiency – All India
2. Species with high marketing efficiency
3. Species with low marketing efficiency
4. Trend analysis of Export of major marine products to total export







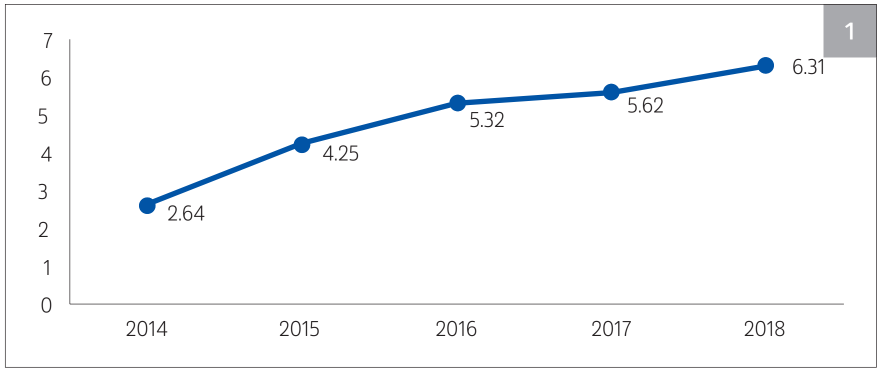
and other aquatic invertebrates for enhancing the revenue generated through value addition

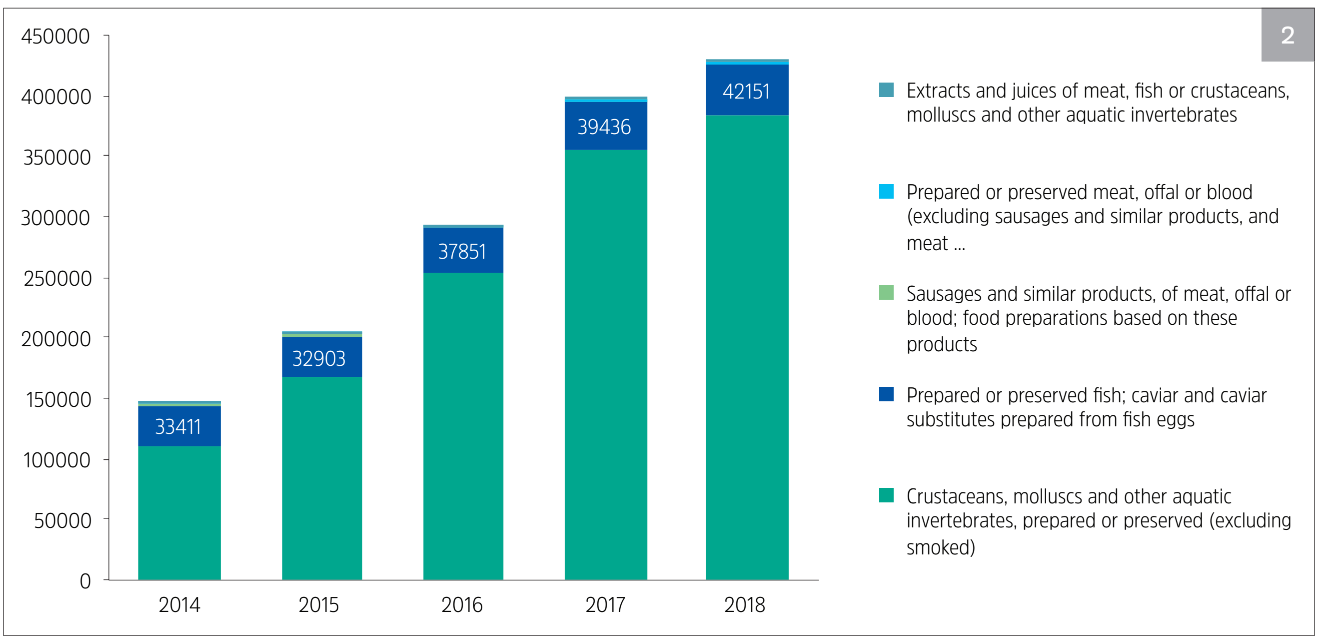
E- Marketing intervention in Indian fisheries sector "- Develop an integrated Fish Market and Price Information Systems (FMPIS) for Indian fisheries sector

Research Project 1011044

Identification / Sampling of the 1000 fish markets

Based on fish marketing schedules assessments, 1000-1500 fish markets across the states were identified for collecting market and weekly price information during the project period. In the first phase, 500 markets have been identified based on its geographical location, extent of operation, quantum of sales and period since inception. These markets include landing centres, production, wholesale, retail, way side and terminal markets. Schedules such





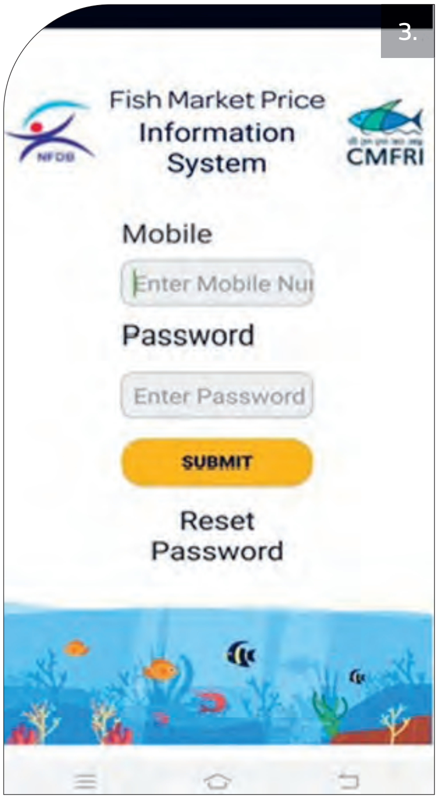
as market structure (MAS) and market prices (MAP) were developed for the data collection of the same.

Development of web portal with technical inputs

The web portal along with mobile application was developed by NFDB with technical inputs from CMFRI. CMFRI has provided the source code for the previous Indian Fish Market Grid which was developed in CMFRI to the IT Team of NFDB. The web portal showcases four domains namely, fish, market, price information system and e-auctions. The information relating to the domain (markets and price information system are already being provided to IT Team, NFDB for initiating the web portal template and design development. The details on the domain fish will be developed by CMFRI and be shared with NFDB.

Tablets to ensure mobile connectivity

The weekly price data collection were entered in a menu driven customized tablets providing real time data to the hub located at NFDB / CMFRI. It includes a FMPIS dashboard with update info, species info and update market location. Species info includes details regarding the species common name, scientific name and its vernacular name, date of collection, price list for each size range. Market information includes details regarding market name, State, District, Taluk, Block, Gram Panchayat, Municipal Corporation, location, type of market, market timings and year of construction. The data was made available to the web portal for showcasing price details and for generating periodic reports. The real time dissemination of the price data collected was enabled though mobile connectivity with the purchase of SIM cards through a corporate deal. These SIM cards are basically meant for

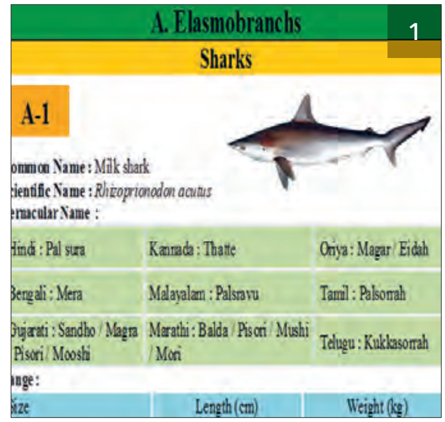


1. Share of value added products to total fish export over the years (in percent)
2. Status of product wise export from India code Harmonic Code –16
3. FMPIS android application
4. FMPIS data collection gadget - Tablet
5. Fish trade at selected markets

the purpose of data dissemination and sharing photographs related to the fish markets. The tablets were given to the enumerators from the fish markets and standardized in terms of its operational ease and maneuverability.

Engaging enumerators for the different identified markets

Enumerators who are into fish marketing were identified from the selected fish markets which are involved in the study. Each enumerator was trained for data entry in the tablets for the different species indicated in the market price schedule. Using the mobile connectivity available in the tablets the price data collected were shared to the hub. These enumerators were given a small remuneration of ₹1500 per month for the services they offer.



Data collection and selection of enumerators

Development of field manual

A field manual with 150 fish species in which 120 Marine species and 30 Inland species mostly traded in the different fish markets in India was developed to include in the software developed for the tablets with their common names, scientific names, and vernacular names across different coastal states for the data collection of the FMPIS project. The manual intends to capture the prices of the fish species traded based on their size range in different fish markets. Each fish species is denoted by an alphanumerical code. The alphabet indicates the group and the number indicate the species. The vernacular name indicates the most common in the state and there could be many names within different locations across the state. The size ranges categorized under three categories viz. small, medium and large with their indicated length-weight range and counts. Length is measured in centimeters and weight in kilograms.

Stakeholder's conclave

A series of stakeholder's conclaves were conducted in the states of Andhra Pradesh, Kerala, Maharashtra, Tamil Nadu, and Telengana for the reinforcement of the FMPIS project. The participants included officials from department of fisheries, Market officials, Data enumerators, Marketers. They created awareness about the project on the selected enumerators/ contact persons who will be associated with the data collection and onwards transmission of data through the tablets with mobile connectivity.

Global Understanding and Learning for Local Solutions: Reducing vulnerability of marine- dependent coastal communities (GULLS)

Project Code: 1004280

The final report of GULLS Project was developed and has been submitted to the funding agency. The outcomes suggested that climate change impacts are global but solutions need to be local. The study provided an insight into the development of climate resilient world with the proactive planning and participation of the fishers using a bottom up approach. Numerous alternative livelihood options were identified, communication tools developed and linkages across the different local self-help governments strengthened

Trans-disciplinary tools were used through participatory frameworks for assessing the opportunities and threats in the coastal community wherein the economic impact on environmental vulnerability was assessed. The changes environment which impacts the coastal community were the direct components considered for exposure whereas financial necessity and social dependence are the components for sensitivity. The components of adaptive capacity are mainly the approach, insight, acclimatizing ability and resources. In addition, the sub components associated in the framework gives priority for nurturing the fishing culture; environmental awareness and communal resilience are part of the sensitivity side. The fisher folk and the different parameters included in the fishing activities were sensitized on identifying the cultural importance of fishing i.e., the traditional / cultural values, the involvement of young generation and their willingness to involve into fishing activities are strongly considered in adaptive capacity. The indicators of interest in environment include idea to sustain local fisheries knowledge the fisher folks possess. The impacts on fisheries were catch reduction, migration of fishes,

1. Field manual for data collection

2-4 Fish trade across selected fish markets

and occurrence of invasive species, varied catch composition, phenology and distribution. The impacts on fisher community were reduction in fishing day's income, seasonality in employment, food security issues, displacement and migration, increased cost of fishing.

Benchmarks for ecosystem assessment: Indicators and guideline for practical ecosystem based fishery management–LENFEST Human Development Index of coastal fisher communities of Kerala, India

Under this project, the diverse components of Human Development Index (HDI) across the fisher folk communities of Kerala, India were reviewed. An attempt was made to construct the HDI for the coastal fisher communities of Kerala following the three components of HDI such as education, life expectancy and GDP formulae employed by the UNDP. The results are a set of values compared with the HDI values across the country and state with reference to the available secondary literature and human development progress reports.

It is important to note that HDI values are a central focal point of reporting human development. However, it is also recommended to bring out the economic data artifacts and related league tables as compliance for policy makers and managers to prudently review the recommendations on improvising the economical standards of these core communities with sustainable efficiency. Moreover the study ascertained the improved HDI of the fisher community on account of improved literacy and age standard of Kerala comparable to global standards. The income continues to a deterrent towards higher HDI mainly attributed on account of fishing being a prime source of income, inherent seasonality, disinterest and inappropriate options towards alternative source of income.

Estimated three dimensions of HDI for the fisherfolk of Kerala

Dimensions	2005	2010	2016
Income	0.364	0.409	0.577
Literacy	0.556	0.578	0.668
Life expectancy	0.817	0.832	0.832
HDI	0.549	0.581	0.684

1. A non-mechanised fishing unit

Socio-economic assessment of marine fisheries resource and management in India

Research Project SEE/SOC/33

Economic efficiency indicators of different fishing units in Kerala for the year 2019 revealed that the highest gross revenue and net operating income were received for Multiday trawl nets operated with high speed Chinese engine. However, these trawlers showed low economic efficiency with high operating and input-output ratios. Resource use efficiency of the high speed trawlers indicated that 1% increase in quantity of diesel used increased gross income by 0.363%

Economics of marine fishing units in Kerala (2019)

Particulars	Mech. Trawl (Chinese)	Mech. Trawl (Indian)	Inboard Ring seine	Mech. Gillnet
Crew wage (₹)	131515	26932	47196	132118
Fuel cost (₹)	290704	43599	23422	134252
Auction charges (₹)	47487	3480	4672	31949
Crew bata (₹)	30416	3480	1216	21513
Other expenditure(₹)	45028	18940	3153	80535
Total operating costs (₹)	545150	96431	79659	400367
Gross revenue (in ₹)	791463	136893	116797	532485
Net operating income (₹)	246313	40462	37138	132118
Operating ratio	0.75	0.70	0.68	0.50
Catch (kg)	4438	751	789	3284
Average crew size	13	10	41	14
Labor productivity (in kg/crew/trip)	351	75	19	235
Total input costs	383219	62539	26575	246736
Input-output ratio	0.56	0.46	0.23	0.46
Gross value added	408244	70874	85550	285749

Economics of non-mechanised fishing units in Kerala

Particulars	OBRS(Ernakulam)	OBRS(Alappuzha)	Thermocol boats(NM)
Crew wage (₹)	9927	3937	843
Fuel cost (₹)	4730	3856	
Auction charges (₹)	1701	322	26
Crew bata (₹)	1923	729	
Other expenditure(₹)	139	278	108
Total operating costs (₹)	18420	8900	869
Gross revenue (in ₹)	28347	10888	1047
Net operating income (₹)	9927	1987	178
Operating ratio	0.65	0.91	0.88
Catch (kg)	210	108	18
Average crew size	19	7	1
Labor productivity (in kg/crew/trip)	11	16	18
Total input costs	6570	4456	124
Input-output ratio	0.23	0.54	0.14
Gross value added	21777	6653	1021

showing overuse of diesel in the sector. The economic efficiency of inboard ring seiners showed a declining trend during the period 2014-19. The net operating income per fishing trip declined from ₹59,936 in 2014 to ₹37,138 in 2019.

In the case of motorised units, the outboard ring seiners in Alappuzha had the lowest capital productivity with operating ratio of 0.91. The gross revenue and net operating income for OB ring seiners declined by nearly 50% compared to the previous year owing to the sharp decline in the catch of oil sardines.

Fisheries Governance, Livelihood and Gender Welfare

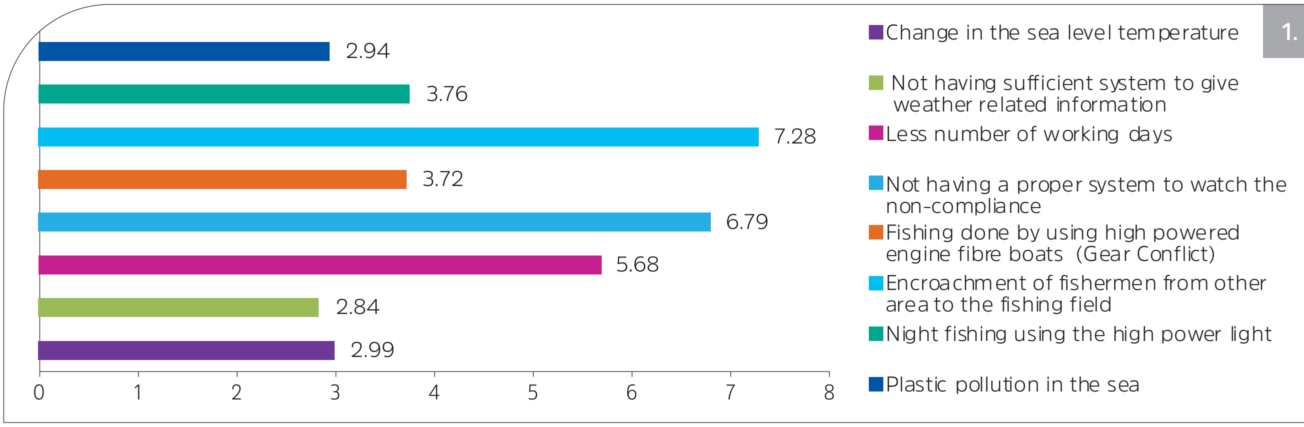
Research Project SEE/GOV/34

Responsible marine fisheries governance: compliance analysis and peripatetic capacity development

1. Perceived constraints which need CD interventions
2. Age wise distribution of fishermen
3. Distribution of fishermen based on the ownership of boats
4. Distribution of fishermen based on the share in boats

A study was carried out to know about the general perception about Kerala marine fisheries regulations, compliance status and the cognitive deficiencies which need capacity development (CD) interventions among the fisher folk. To get a cross-Kerala view, data were collected from various landing centres including Kovalam, Vizhinjam, Valiyathura, Paravoor, Pozhikkara, Kollam, Wadi from Thiruvananthapuram and Kollam region: Chombala, Beypore, Thanure from Calicut and Kannur region: Nileshwar, Thaikadapuram, Madakkara and Azhikkal from Kasaragod and Kannur region.

Interaction with fishers from different sectors mainly trawlers, ring seine operators, and traditional fishers revealed that a general perceived reduction is in the fish availability in entire region, especially in case of mackerel and sardine fish. Fishers perceived that the night fishing using the high-power light, pair trawling, fishing using boats with high powered engine are the main reasons for the reduced availability of the fish. Perceived constraints which need CD Interventions were analysed. It was observed that encroachment of fishermen from other area/state to the fishing field of the fishermen (sampled for the study) was the major issue (mean rank 7.28). Fishermen from all the three zones



(south, central and north) perceived that the non-compliance of the rules and regulations under the Kerala Marine Fishing Regulations (KMFR) was very severe due to inadequate monitoring of the enforcement wing (mean rank =6.79). They have also perceived that the trend of getting a smaller number of active working days (fishing days) as another major problem as it has impacted their livelihood and the income sustainability. It was mainly attributed by the irregular weather conditions and successive floods during last two years. Other major problem ranked by the fishermen was the illegal practice of night fishing with the high intense lights (much higher watts than authorized) (mean rank = 3.76). Gear conflict was another major issue as perceived by the trawlers (mean rank = 3.72). They blamed that the big fiber boats engaged in the fishing activities were having a high-power motors which are many times higher than the allowed power range and they are doing fishing in an unsustainable manner. They apprehended that the imprudent categorization of fishing boats prevailing in the current situation, seconded with different types of seasonal and spatial restrictions make the trawling as a less profitable venture as compared to the fibre boat fishery. Though the climate change and related issues were also perceived as a major problem which need capacity building interventions on mitigation and adaptation aspects, these were ranked least important than others (not having the weather forecasting system, mean rank = 2.84 and the increase in the sea water temperature level (mean rank = 2.99).

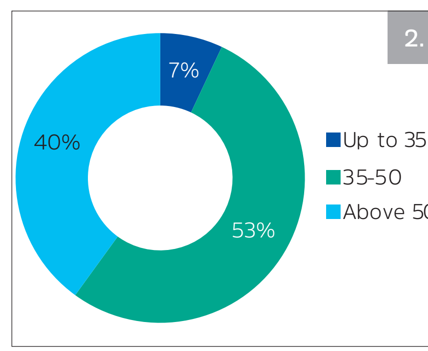
A case study was conducted among the ring seine fishermen to understand the present status of the compliance, so as to decide the areas which need capacity development interventions in a focused manner. Among sampled fishermen (N=80), 53 % of them were in the age group of 36-50 and 40 % of them were above 50 years of age.

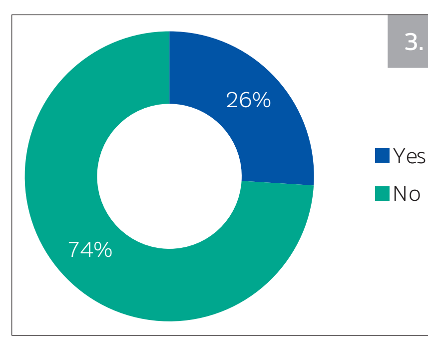
Seventy four percent of them were not having own fishing boat or ownership in it.

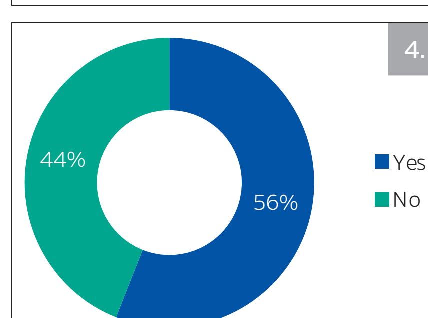
56% of the fishermen who do not have ownership in the boat but have share in it and 44% of the sampled fishermen were labourers or workers.

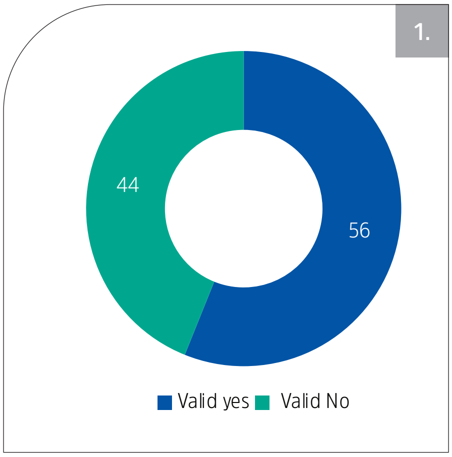
67% of the fishermen responded that, their relatives are their co-workers in the fishing boats.

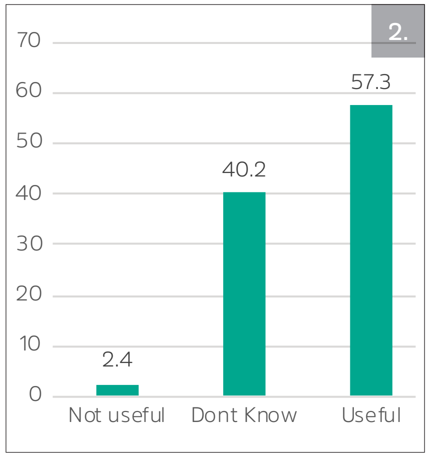
When asked about their opinion on MLS, 57.3% of the ring seine fishermen responded that the regulation is very

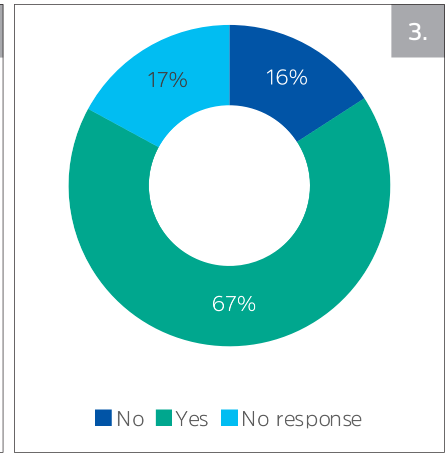




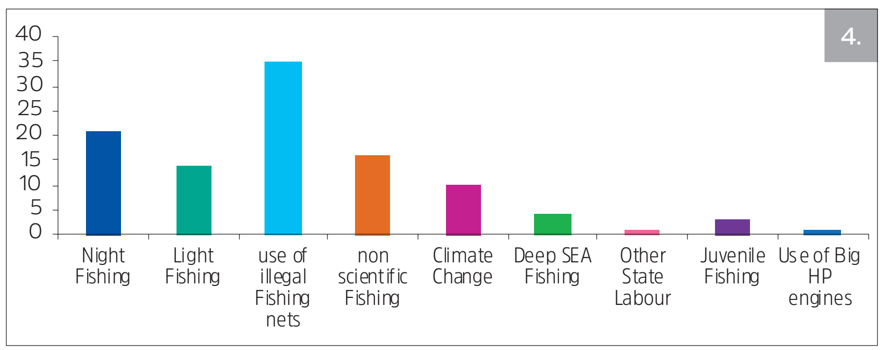




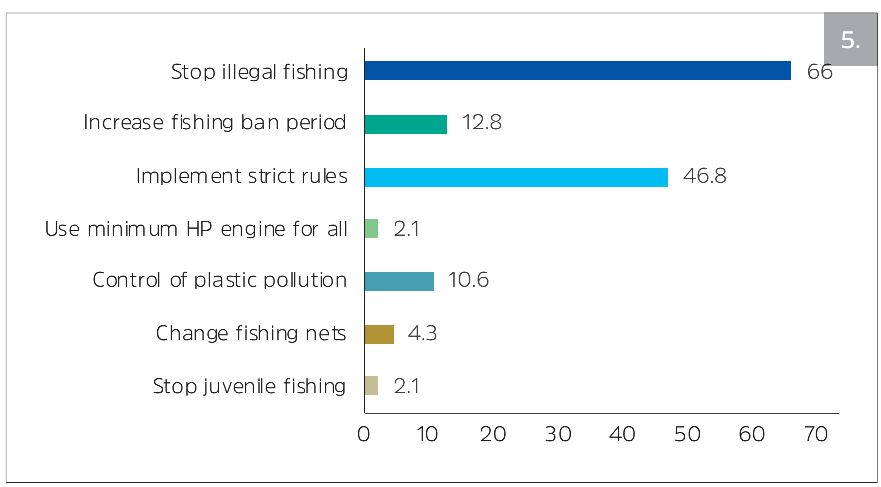




useful in fish resource conservation. But 2.4% of the respondents expressed that it is not a useful regulation for resource conservation and at the same time 40.2 % of them responded that they have no idea about its usefulness (do not know) or did not have any experience to agree(disagree) with the positive impact of MLS in marine resource conservation.



Perceived reasons for the reduction in the fish resource availability were analyzed. Use of illegal fishing nets, night fishing and non-scientific fishing methods practiced were identified as the major reasons for the reduced availability of the fish resources.



66% of the respondents suggested that complete stoppage of illegal fishing activities is very essential to protect the declining fish wealth. Similarly, the strict implementation of the regulations and rules with assured compliance (46.8%) and increasing the duration of fishing ban period (12. 8%) were other two important strategies suggested by the ring seine fishermen to protect the fish stock resources in a sustainable way.

Peripatetic capacity development interfaces were conducted at different locations in association with the Department of Fisheries, Government of Kerala. The interfaces were attended by about 50 each of stakeholders in each location (Chavakkad, as well as Azheekkode in Thrissur district, Ambalappuzhain Alleppy district, and Cochin Harbour in Ernakualm District). The interface at Neendakara was attended by about 150 stakeholders. The focus theme was the “Role of the amended Kerala Marine Fisheries Regulations in Responsible Fisheries Governance”.

Capacity development interfaces CD intervention tools in bilingual (both Malayalam and Hindi) were prepared

to enable effective learning experience among the fishermen.

1. Relatives among co-workers in the fishing boats
2. Distribution of fishermen based on the opinion about MLS
3. Perceived reasons for the reduced availability of fish
4. Suggested Strategies to protect the fish wealth (%)
5. Meetings on Capacity development interfaces
6. CD intervention tools

DLOs practiced in Ramanathapuram district, Tamil Nadu

DLOs (Standalone enterprises)	No. of families	Man-days	Mean Annual Income (₹)	Places
Fisheries				
Boat building (Motorized & Non-mechanized)	70	319	5,42,400	Vedalai, Rameswaram, Kezhakarai, Soliyakudi
Marine Shell Collector	60	228	1,48,200	Ramanathapuram
Shell Processing (Labour)	140	342	1,09,200	Rameswaram, Pamban, Thondi and Keezhakarai
Small-Scale Shell Processing units (Owner)	12	342	7,86,600	Rameswaram, Pamban, Thondi and Keezhakarai
Net mending	30	300	1,26,000	Kunthukal
Transport of Fish from sea shore to the landing using Tractor, cart	80	150	2,40,000	Rameswaram, Pamban, Mandapam and Erwadi
Ice factory (Labour)	300	330	1,80,000	Major landing centres in Ramnathapuram
Non-Fisheries				
Mat making using Coir	65	274	41,040	Pannaikulam and Rameswaram
Mat making using Palmyra leaf	60	180	66,000	Thamaraikullam and Muthupettai

1.

2.

Diversified livelihood options and gender mainstreaming for entrepreneurship development in Marine Fisheries Sector of India

Research Project SEE/GEN/36

Extensive field surveys were undertaken in Ramanathapuram district of Tamil Nadu, for the documentation of fisheries related/non-fisheries related diversified livelihoods (DLOs). Data were collected on the number of families engaged in the enterprises, man-days involved and the mean annual income generated by the practice of these enterprises.

It could be observed from the Table above that among the fisheries related enterprises, the highest mean annual income was obtained from owners of small-scale shell processing units to the extent of ₹7,86,600. This is widely practiced in Rameswaram, Pamban, Thondi and Keezhakarai areas of the District, with 342 man-days of work. This was followed by Boat building by fishers of Vedalai, Rameswaram, Kezhakarai and Soliyakudi. The owners of boat building units consisting of both mechanized and motorized units earn on an average mean annual income of ₹5,42,400 with 319 man-days of work. Under the non-fisheries sector, the highest mean annual income was obtained by fishers practicing mat making using palmyrah leaf. (₹66,000) with 180 man-days of employment. Mat making using palmyrah leaves is practiced in Thamaraikullamand and Muthupettai areas of the district. It is observed that all the fisheries related/ non-fisheries related enterprises are standalone enterprises.

On the basis of impact study on 1000 'Self Help Groups' in gender mainstreaming in marine fisheries sector, representing 30 micro enterprises, assessed the level of performance and extent of empowerment of SHGs through appropriate indices of measurement. Identifying the relevant fishery based micro enterprises catering to the location specific needs of the SHG members, 100 Entrepreneurial Capacity Building (ECB) Training programmes on the identified micro enterprises by appropriate HRD intervention programmes and 250 fisherfolk interaction meetings were organized. Economic Feasibility analysis of 30 fishery based micro enterprises accomplished by SHGs, and 30 allied sector microenterprises, were video graphed and business plans of the microenterprises were also developed. The main constraints faced by the women entrepreneurs while doing the different income generating activities related to fisheries were analyzed for making strategic recommendations. 100 success cases documented so far on ECB of SHGs with special reference to gender perspective. 25 video documentaries were brought out as a gender mainstreaming series of success stories on Impact of SHGs. An exclusive data base on SC beneficiaries based on the economic feasibility analysis and preference ranking of appropriate fishery-based microenterprises was generated and the beneficiaries were identified. The constraint analysis of SHGs of women fisherfolk in all maritime states in India and Lakshadweep are highlighted in the Table.

Under the DST Project, three interventions for the mobilized SHGs of SC fisherfolk were undertaken.

1. Raft planting in seaweed farming
2. Seaweed farming at Ramanathapura

Various enterprises of SHGs, Performance Level, Empowerment Index, Break Even and Pay Back Period

No	Micro Enterprise (Fisheries)	No of SHGs= 1000	Avg. Level of Performance	Avg. Empowerment Index	Break Even Point	Pay Back Period (Years)
1	Fertifish unit	20	72.8	0.82	1145 kg	1
2	Chinese dip net	12	79.2	0.89	1800 kg	1.7
3	Aqua-tourism	15	78.9	0.88	29938 units	3
4	Clam processing	75	57.3	0.68	8004 kg	2
5	Pickling unit	75	72.3	0.83	3680	0.8
6	Fish drying	60	70	0.78	4240	0.9
7	Fish Cold Storage Unit	18	70	0.8	3730 kg	1.02
8	Fish vending unit	70	69.2	0.78	11,300 kg	1.27
9	Mussel culture	60	76	0.84	95.29	1
10	Oyster culture	60	75.9	0.82	1132 units	1
11	Shrimp culture	30	59.6	0.69	650kg	1
12	Quarry fish culture	20	58.8	0.64	649 kg	1.8
13	Cage farming	50	72.2	0.82	187 kg	1
14	Ornamental fish culture	60	54.5	0.67	221633 fries	1.28
15	Pearlspot culture	15	67.5	0.78	30 kg	1
16	Tilapia culture	15	65.5	0.76	50 kg	1
17	Bivalve collection	30	69.2	0.77	8000 kg	2
18	Seaweed farming	30	77.6	0.86	10080 kg	1
19	Fish Amino units	22	75.4	0.84	361 units	0.85
20	Ready-To-Eat Fish Products	25	74.4	0.83	7680 units	1
21	Ready to Cook Fish Products	25	71.4	0.81	4833 kg	1.24
22	Crab Processing	25	68.3	0.77	3086 kg	0.92
23	Aquaponics	40	60.2	0.71	380 kg	0.35
24	Fish feed production	20	59.3	0.61	1900 kg	056
25	Seafood Kitchen	18	78.7	0.88	34618	3
26	Fish procuring unit	40	79.5	0.87	12000 kg	1.2
27	Pearlspot seed production Unit	10	67.5	0.79	150000 fries	1
28	Paddy cum fish culture	30	74.9	0.83	-	-
29	Fish Aggregating Devices	10	80	0.89	-	-
30	Hand picking fishing unit	20	50.1	0.61	-	-

1.

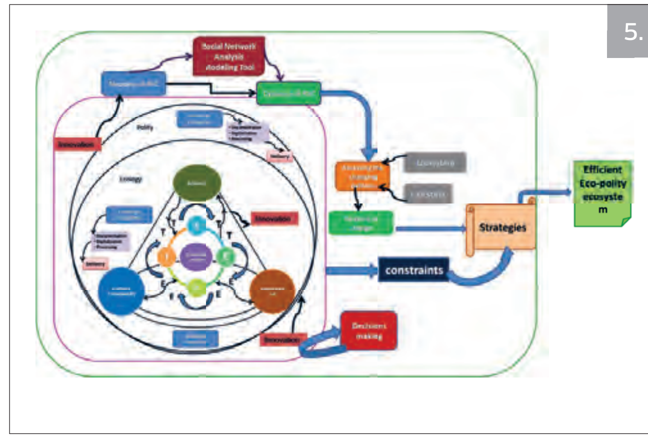
2.

3.

Cage farming: In Kambithazham in Edavanakkad, by mobilizing SHGs with the assistance of KVK to the 10 members of the SHG and a cage of 4 x 4 m was fabricated and 800 seabass juveniles were stocked. An exhaustive 2 days training programme and demonstration sessions were organized in collaboration with KVK. An outer net covering also was provided for ensuring additional protection. Crushed prawn and other low value fishes were used as feed for stocked fishes; feed was broadcast 3-5 times a day in the early stage. Periodical cleaning of net was done to remove fouling organisms and algae. Culture period lasts for 6-8 months.

Pearlspot Seed Productiont: Being widely preferred for cultivation in backwaters and freshwater, Pearlspot seed production unit was initiated in Vallarpadam in a pond of 50 cents with adequate water supply and other facilities and with the technical assistance from KVK, During initial stalking, 200 brooders of pearl spot were introduced in the breeding pond.

Fish Fertilizer: At Cherai, with focus on livelihood, and effective utilization of wastes from fish based industries, a fertilizer unit entirely depending on fish waste collected from various fish based ventures was established for an SHG of 10 SC beneficiaries. 2 days training programme and demo sessions were organized in collaboration with KVK, and the established unit of the same is operating successfully.



1. Cage farming in Edavanakkad by SHGs under DST project
2. Training for Fish Fertilizer unit in Cherai
3. Pearlspot seed production pond
4. Workshop at Govt. FHSS, Kaipamangalam
5. Conceptual frame work of knowledge value chain analysis

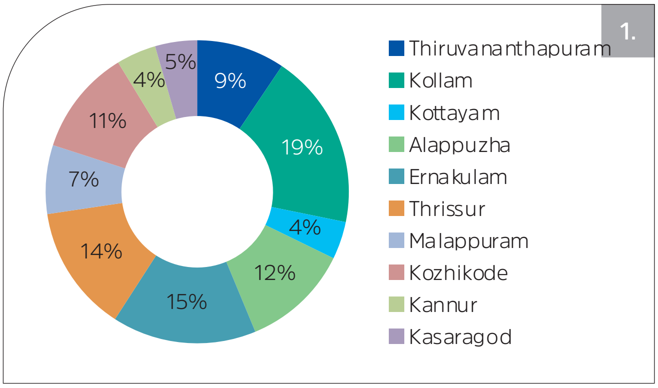
ICAR Extramural research project -Pedagogic and pragmatic dimensions of vocational education system: A diagnostic study on employability of fisheries students

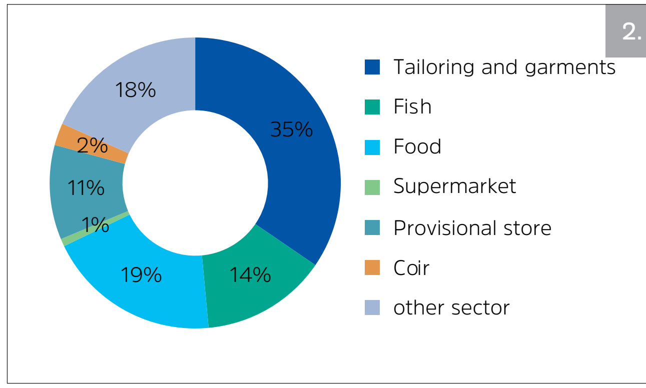
Socio Economic Evaluation Technology Transfer Division (SEETTD) of Central Marine Fisheries Research Institute (CMFRI), Kochi organized satellite workshops on 'Vocational education and employability' under ICAR-Extramural Research Project "Pedagogic and pragmatic dimension of vocational education system: A diagnostic study on employability of fisheries students'.

The purpose of the workshop was to provide a platform for more detailed knowledge-sharing and to discuss various career opportunities and higher studies options, after the completion of higher secondary education. General inattentiveness was observed in the fisheries technical and vocational education system in Kerala to give career orientation for the students. This inadvertent negligence compelled the students to opt for some other job areas in which they need to be re-skilled to perform, while making a wider demand and supply gap in the labour market in fisheries and related filed for which they are actually skilled. This scenario motivated us to design an innovative model of career guidance workshop in fisheries sector, with the intention to enlighten the students about various platforms in which they can perform better with the acquired vocational skills. Launching workshop was on 06-12-2019 at Govt. FHSS, Kaipamangalam, Thrissur in which 75 students and 8 teachers were participated. In this workshop apart from the career guidance, an experience sharing session by the alumni of the schools who are well occupied and employed in different fisheries sectors under public, private and self-employed organizations and motivational talks by the eminent scientists working in the fisheries sector were also included.

ICSSR IMPRESS- Knowledge value chains for sustainable marine fisheries management: A diagnostic assay in an eco-polity spiral system of governance

The conceptual frame work of knowledge value chain analysis for sustainable the marine fisheries management and governance was prepared.





Labour mobility in marine fisheries sector

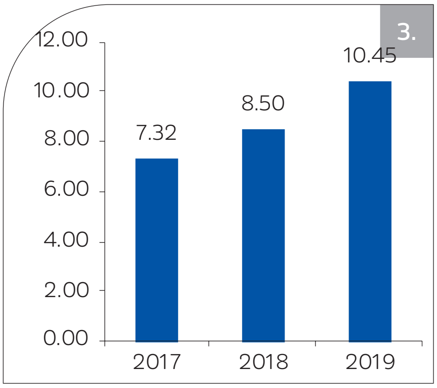
The migration of labour has become an important feature of the globalizing world, accompanied with many economic, social and political concerns. Attempts to estimate the pros and cons of labour migration in the marine fisheries sector by analyzing the cases of fisher folks from various part of the country were made. In a study done in the five coastal states of India using simple random sampling method, about 380 respondents were included from Tamil Nadu (60), Karnataka (100), Maharashtra (100) and Gujarat (120). The study identified unemployment and seasonality of labour were the main limiting factors faced by the workers in fishing industry which necessitated the need for the labour migration. The study indicated that most of the migrant fishers migrated with their families. The study identified low income and education levels as the main reasons for migration. The expenditure pattern of the migrants at their workplace as well as their home were analysed and the results indicates that when comparing the expenditure before and after migration the expenditure on food shows slight decrease after migration. The improvement in the social status, possession of assets and the improvement in the quality of education were the major achievements of migrant fishers whereas difficulty in the language and competition amongst the fellow migrants were the major constraints during migration. The study revealed that regardless of their nativity, the workers are earning and saving after migration and are leading a peaceful life with reduced financial liabilities. The readiness of migrants to work at lower wages might affect the standard of living of the local fishermen over years. Consequently, there is an immediate need to ensure that fishermen especially the younger generation of the local fishers are to be motivated to continue in fisheries coupled with technology support so that the attrition can be kept under control.

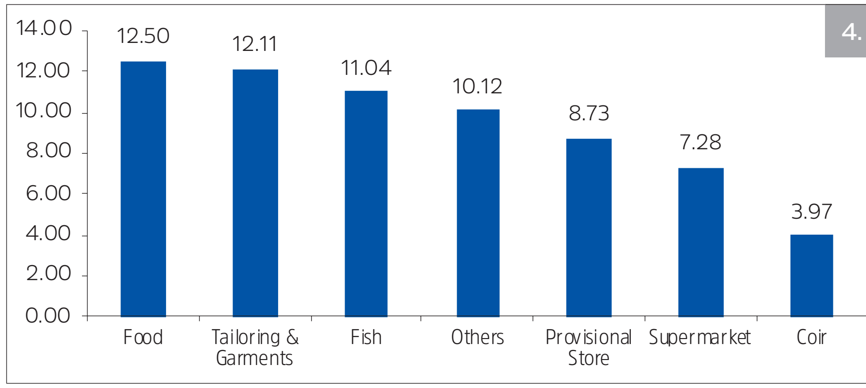
Assessing the financial viability of Theeramythri enterprises through Benefit Monitoring and Evaluation (BME)

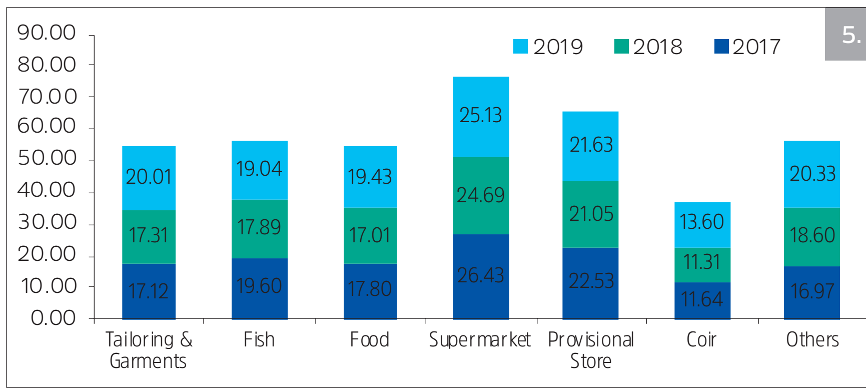
Research Project: 1010080

Theeramythri program envisaged to provide alternative livelihood options for the fisherwomen thereby focusing on the social, economic and gender empowerment of the targeted group. Through benefit monitoring and evaluation of the strengths, weakness, opportunities and limitations (SWOL), the project was documented to give creative recommendations for enhancing the benefits to the target population. Comprehensive assessment of the activity groups in terms of livelihood benefits namely, improvements in social, economic and human capital, and its effects in improving their quality of life was the focal area of the study. Moreover analysis of the effectiveness of different components of the SAF such as training, financial assistance, revolving fund, federations, branding and marketing support, and institutional structures for local management on individual and group empowerment process were assessed. A performance assessment on the role of the different stakeholders was undertaken to understand the dynamics of forward and backward integrations along the chain. Theeramythri being a Public, Panchayat, Professional Partnership (PPPP) model, a road map was developed for the improved effectiveness and effective implementation for ensuring and economically viable units.

Benefit monitoring analysis- Benefit monitoring analysis of the business done in the activity groups was done for district wise and sector wise for the period of 2017-19 to assess the different financial parameters which included







1. Benefit Monitoring and Evaluation of Theeramythri Enterprises–Theeramythri Units (Districts)
2. Benefit monitoring and evaluation of Theeramythri enterprises–Theeramythri Units (Sector wise)
3. Average sales volumes of 2017, 2018 and 2019 (₹lakhs)
4. Average Sales volume across the different sector (₹Lakhs)
5. 5. Employment generation across the different sector (man-days/ month)

sales turnover ratios, asset ratios wage rate and average employment days. The district wise and sector wise units selected is given below.

Average sales volume

Sales volume is the total amount generated as the result of providing/ selling services or products. The average sales volume during 2017, 2018 and 2019 are indicated.

The assessment of the sales volume across the different sector indicated that the food sector registered the highest (₹12.50 lakhs) and lowest for coir sector (₹3.9 lakhs)

Employment generation

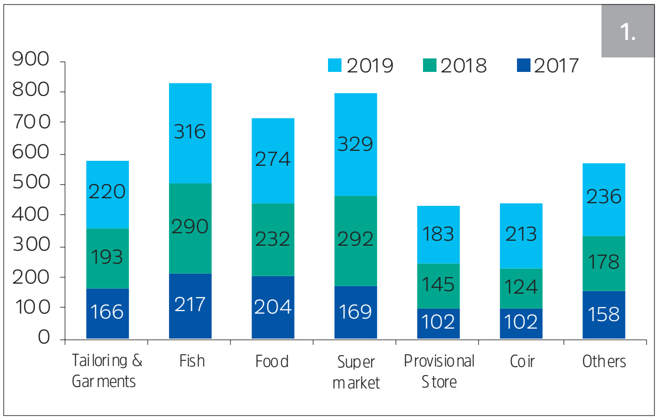
Employment generation of fisherwomen has been one of the important objectives of Benefit Monitoring and Evaluation (BME) project. The average man days generated across the different sectors was found to be 20 ranging from 25.1 in the case of super market to 13.6 in coir sector.

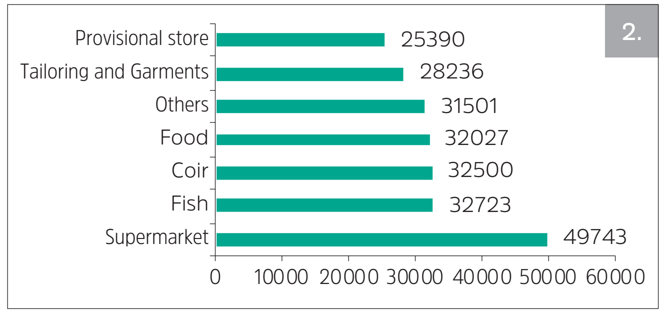
Wage rate

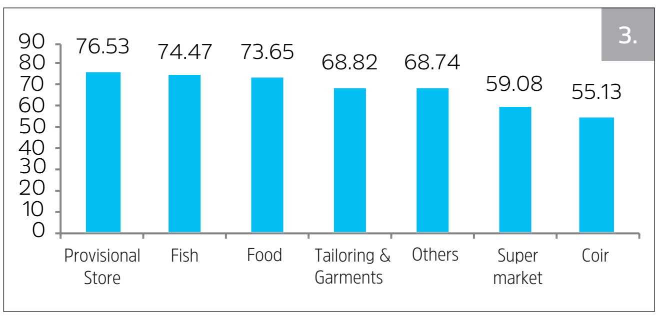
The wage rates realized for the employment contributed varied across the sector. The average wage rate increased from ₹160 in 2017 to ₹253 in 2019. The wage rates were the highest for the supermarket (₹329) and lowest for Provisional stores (₹183).

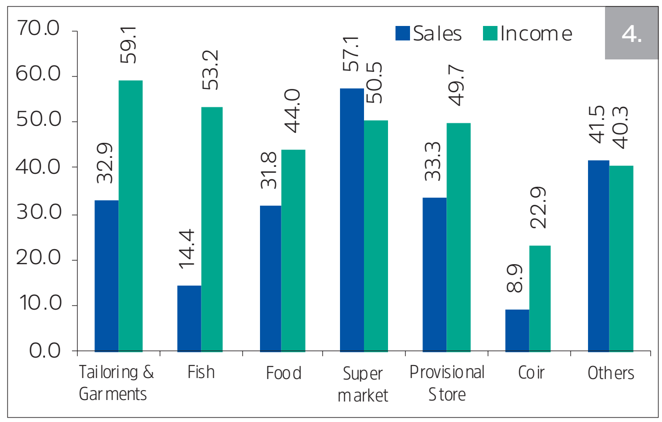
Initiatives in assessing impact of Theeramythri additional funds.

SAF has a strong budget position for the implementation of the Theeramythri groups. There are different kinds of funds which are made available to the activity groups such as revolving fund, technology fund and shift to appropriate business. The study assessed the impact









of these funds in augmenting the performance of over 600 activity groups in Kerala. The results showed that both sale turnover and income increased consequent to receipt of additional fund. The repayment rates were also high over 70 percent showing promising future. The results also indicated the need for identifying non-traditional business. "Other" category enterprises targeting the future target younger fisher women group members.

Revolving fund

Revolving fund (RF) provides working capital support for existing enterprises without interest. The loans extended from the existing revolving fund have already emerged as an important source of working capital funds for the groups. Groups, that had gone down in performance due to problems in working capital management have benefited from this opportunity. When considering the revolving fund received by the sectors, an average of ₹33160 was received by all the sectors. The highest amount received by supermarket sector (₹49743) and lowest amount received by the provisional store sector (₹25390).

After receiving the revolving fund, the sales as well as income of different activity groups increased. The repayment ratio (amount repaid/ amount received) was the ratio of amount received and amount repaid is calculated. It shows that highest ratio in provisional store sector followed by the fish sector and lowest ratio in supermarket sector. This is due to the variation in revolving fund received. Supermarket sector received more amount and provisional store sector received less amount among the sectors.

Technology fund

SAF provides technology improvement support that focuses on technical improvement, replacement and repairs, technical support, and application of new and appropriate technologies. The activity groups implemented by SAF need to be developed by extensive application of new and appropriate technologies in various micro enterprises. These increase the demand for interventions in technology improvement and skill training. After receiving the technology fund the sales and income of the activity groups increased.

Impact on Technology Fund

After receiving the technology fund the sales increased by 34 per cent and income of the activity groups increased by 45.7 per cent. The sales and income increase across the different sectors is shown the highest in provisional store sector and least in supermarket sector.

The major reasons for availing technology fund across the sector is given in the Table.

1. Wage rate across the different sector (Wage/ man day)
2. Average Revolving fund received (₹)
3. Repayment status of revolving fund across sectors (%)
4. Impact on Technology Fund on sales and income

The major attribute for the motivation to get additional revolving fund

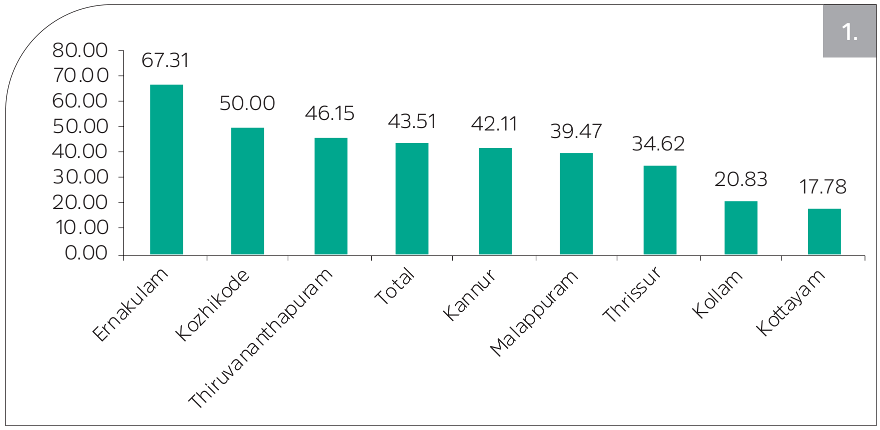
Attributes	Score	Rank
Enhance the sales volume	68.0	I
Increase the personal income	59.0	II
Purchasing the raw materials	54.0	III
Ease of availability	53.0	IV
Creation of job opportunity	52.0	V
Low cost and high business performance	48.0	VI
Meeting the day to day expenses	47.0	VII
Less burden and procedures	46.5	VIII
Marketing the products	46.0	IX

Reason for availing technology fund

Attributes	Score	Rank
Enhance the productivity and sales volume	64.0	I
Increase the income	60.3	II
To meet the demand	57.4	III
Ease of availability	53.6	IV
Creation of job opportunity	48.1	V
Providing best service by saving time	47.7	VI
Low cost and high business performance	47.1	VII
To stay competitive	43.1	VIII
Less burden and procedures	41.3	IX

Reasons for shift to appropriate business

Reasons	Score	Rank
Economic reality	68.6	I
Current business activities, products and services do not generate the revenue, necessary to sustain profit	65.2	II
Better chance of developing new revenue	63.4	III
To lower prices and discounts to attract more customers	55.8	IV
Not able to keep a quality image	49.8	V
Social demand	49.6	VI
Social pressure	48.0	VII
Custom demand	47.4	VIII
Governmental regulations	47.2	IX
Change in customer preference	46.6	X
Increase in consumer demand	45.6	XI
Crisis and pressure	39.0	XII
Seasonality of business	33.2	XIII



Shift to appropriate business

Shift to business funds are provided to activity groups when there are not viable options for reviving the activity group. These groups are facilitated to take loan from banks. The major reasons observed for the shift to appropriate business are given in the Table.

Shortcomings in the Business

The activity groups continue to face many constraints in developing its business and are listed in Table below

Effectiveness of Theeranaipunya- Capacity building for fisherwomen youth

Theeranaipunya is a capacity building training programme for the fisherwomen youth. The positive impacts after attending the Theeranaipunya training programme is given in the Table below.

Effectiveness of Theeranaipunya

The main effectiveness of Theeranaipunya based on the trainees perspective is the wide lecture topics and better access to online material followed by sufficient and well-equipped faculty team and favourable training environment.

Activity groups constraints in developing its business

Constraints	Score	Rank
Competition in market	63.4.	I
Lack of Institutional linkages	61.0	II
Lack of branding	57.7	III
Unexpected expenses	56.6	IV
Inadequate funds	55.0	V
Lack of skill in business planning	53.4	VI
Seasonality of business	53.3	VII
Inadequate operational space	50.7	VIII
Raw material shortage	50.0	IX
Lack of skill up gradation	48.9	X
Quality issues	45.7	XI
Absenteeism	44.6	XII
Conflicts among members	44.0	XIII
Technical support from SAF	41.0	XIV
Delay in disbursal	39.3	XV
Fund spent on other uses	36.3	XVI

Theeranaipunya placements

After Theeranaipunya training program 83.5 per cent of the trainees searched for a job got job in different organisations which included private firms and government agencies. When comparing the different districts where the Theernaipunya trainees are currently placed it was found that Ernakulam district provided placements for 67.30 % of trainees followed by Kozhikode (50.00%)

Theeranaipunya positive impacts

Attributes	Score	Rank
Communication Skills	64.9	I
Leadership Qualities	63.4	II
Economic benefits	55.3	III
Decision making skills	49.8	IV
Personality development	48.5	V
Career prospects	48.3	VI
Status of living	48.1	VII
Management strategies	44.6	VIII
Accomplishments/Satisfaction	38.5	IX
Others	26.4	X

Effectiveness of Theeranaipunya

Attributes	Score	Rank
Wide lecture topics and better access to online material	61.9	I
Sufficient and Well-equipped faculty team	61.3	II
Favorable Training Environment	60.4	III
Interactive lecture sessions	58.5	IV
Best experiential training institutes	57.3	V
Systematic and comprehensive training assessment	53.1	VI
Perfect time schedule	48.8	VII
Perfect technologies and facilities for training programme	47.1	VIII
Enhanced the career development of trainees	39.5	IX
Others	21.4	X

1. Current employment status
2. Stakeholder's workshops

Stakeholder's conclave

The stakeholder's conclave was jointly organized by CMFRI and SAF. The group members of this project rarely have a chance to share their experiences and to review together their existing problems. A series of stakeholder's conclave was organized in order to try and address these needs. The stakeholders meeting gathered around 120 participants which represented the different activity groups from different sectors. The main objectives of the stakeholder's conclave was to bring together different stakeholders among different sectors, carry out a mapping exercise of the activity groups by analysing what happens in the field, One to one discussion with the group members understanding problems in general and to provide stakeholders with some expert input on qualitative and the other aspects to be considered in their working and provide training on the Theeramythri Information on Monitoring Evaluation System (TIMES) Register.

Fishers' welfare impact assessment on the satellite-based ocean information services: An appraisal

Research Project 1010246

The project attempts to gauge the extent of adoption of information services and realizes correlation with the socio-economic attributes of the stakeholders, evaluating the impact of information services on the fishers' welfare. Data assessments were tentatively planned to cover around 4500 respondents across PAN India representing all the coastal states. Around 2586 respondents were surveyed from ten states such as Tamil Nadu, Andhra Pradesh, Odisha, West Bengal, Andaman Islands, Kerala, Karnataka, Goa, Lakshadweep and Gujarat. The proportions of surveyed users and non-users of the services were presented. Data analysis on 2586 samples respondents (1474 users and 1112 non-users of the satellite information forecast by INCOIS) was completed and the results were presented in the following section.

Interim results of the Study

Tamil Nadu and Pondicherry

Seven coastal districts of Cuddalore, Nagapattinam, Kanchipuram, Tuticorin, Pondicherry, Chennai, Rameswaram and Kanyakumari were the locations selected for the study. Overall, 507 individual respondents were surveyed from which sixty percent of the fishers are users of INCOIS services and 40% are non-users. About 60-70% of the respondents belong to the mechanised and motorised fishing sector. Fisher folks of the mechanised and motorised fishing sector are registered users of the INCOIS services. Ocean state forecast information is received on daily / weekly basis to the users as audio advisory services. Electric display boards were deployed in all the fishing harbours and nearby fishing department buildings. However, most of them were seen to be not operative due to mechanical causes. Indigenous traditional knowledge is very widely used. Fishers Friend Mobile Application is mostly used only for geo-referencing operations. Advisory services on frontal areas, species-based PFZ, GPS coordinates to be integrated with the wind, tide and current pattern predictions, GPS coordinates are to be validated, signal and battery related problems on using gadgets/mobile phones, real-time predictions are the recommendations and suggestion reported by the fishing communities of the region.

Kerala

About 523 respondents were surveyed from the coastal villages of Ernakulam, Kozhikode, Kollam, Alappuzha and Trivandrum districts. Surveys were carried out from the coastal villages, Chellanam, Edvanakkad, Neyattinkara (Ernakulam), Vizhinjam (Trivandurm), Beypore (Kozhikode), Wadi, Quilon, Sakthikulangara, Neendakara and Thangassery (Kollam), Thottapally and Thirukunapuzha (Alapuzha). Fisher folks of the village are non-registered under the INCOIS services, but receive information on climate and weather forecast through Indian Meteorological Department. Their source of information is from website access, television, radio and newspapers. These information services were said to be delivered highly on weekly intervals to most of the surveyed regions in Kerala coast. Non-motorized and motorized type of fishing is practiced in this village. Sardine fishing using Ring-Seine is one of the indigenous fishing practices adapted by the fishers through their experience. Water colour and odour, fish shoal appearance and wind-tide directions are the traditional practices used by the fishers in the region for climate forecast predictions and natural hazards. The respondents opined that the scientific forecast services were useful and they require expansion of INCOIS service dissemination with awareness campaigns with representatives of local self-governing bodies of the villages.

Karnataka

140 samples were collected from Dakshin Kanara district of Karnataka. Sixty five respondents are registered users of the INCOIS services since 2014. Climate-weather forecast, wind-tide and current alerts, temperature, Oil-spill, tsunami, storm and PFZ are the advisory services disseminated as audio-advisory calls through mobile phones, television and electronic display boards on both daily and weekly basis. Indigenous practices are adapted from other sources such as books and media and also through experience. In addition, the fishers have requested for real-time climate-weather forecast predictions and PFZ advisories for size and species specific. Integration of traditional practices in the scientific advancements is answered as most effective way of disseminating the INCOIS services to better understand the forecast predictions for fishing practices and climatic conditions. Otherwise non-INCOIS users rely on IMD data from the website, telephone, newspapers and fellow fishers.

Andhra Pradesh

Overall 717 respondents were surveyed from Vishakhapatnam, Srikakulam, East Godavari and Krishna district of Andhra Pradesh coast. Respondents from fishing harbours of each region were collected. 80% of the respondents were aware of the services and 75% are reliable on the forecast delivered by the INCOIS (represented in Level of Awareness and Reliability). Among the 355 respondents were INCOIS information service users, 61% of the users comply with the information forecasted (range of adherence) to them on daily/ weekly basis. From the total respondents, 362 are non-users of the services. Since 2016, INCOIS services were delivered to the fisher folks of the region through fisheries department and village knowledge centres. Climate-weather forecast, Wind-tide and current alerts, temperature, oil-spill, tsunami, storm and PFZ are the advisory services disseminated as audio-advisory calls through mobile phones, radio and fellow fishermen on both daily and weekly basis. Ranking order of different and reliable mode of dissemination was carried out using Garrett scoring method and presented. Fishes such as anchovies, mackerel and carangids are the fish species caught from the PFZ directed by INCOIS. Bycatches obtained from the PFZ are leather jackets and barracuda. Other forecast information services such as wave, wind and tidal patterns are adapted in the medium level on weekly basis. The climate and weather forecast are not frequently delivered to the fishing communities and inconsistencies in frequency of receiving were reported by most of the respondents. Traditional indigenous practices are adapted from other sources and through experience since 1990s. Integration of traditional practices in the scientific advancements is answered as most effective way of disseminating the INCOIS services for better understanding and utilisation related to climate and fishing related activities. Otherwise non-INCOIS users rely on IMD data from the website, telephone, newspapers and fellow fishers.

Odisha

Three hundred samples were collected from three coastal districts such as Puri, Kendrapara and Jagatsinghpur. Most of the users are registered users since 2015. The respondents cover both the mechanized and non-motorized fishing sectors. 149 respondents are users and 151 are non-users of the INCOIS services. Potential fishing zone information services are not delivered to the surveyed fishing areas of the district. But Ocean state forecast information is received on daily and weekly basis through M S Swaminathan and Reliance foundation as audio-advisory call services. Climate-weather forecast, wind-tide and current alerts and storm surges are the ocean state forecast services delivered to the fisher folks of the surveyed areas. Fishers' friend mobile application is generally used for knowing the information. Indigenous traditional practices are still adopted and used for fish catch predictions and harvesting methods. The future requisites are government support in providing gadgets, expansion of information sharing through mobile phones and engaging local self-governing bodies. The Garret scoring and ranking order of future requisites is presented for the Odisha coast.

West Bengal

In total, 150 respondents were surveyed from the Purba Medinipur District of West Bengal. The respondents are the users of the scientific forecast services and are involved in fishing through motorised and mechanised sectors. The ocean information services are received from weather forecast department (could be IMD) through Department of fisheries and are suggested to be less utilized on daily basis. Frequency of usage is medium and the mode of dissemination is through mobile phones, newspaper, other sources and television/radio. The survey also dealt with the maximum gains acquired by using the forecast services. And the respondents articulated that increased catch, less fuel cost, reduced crew size are the possible gains obtained through the different services delivered to the fishing communities. Some of the losses averted are lives saved and reduced occupational losses during the natural hazards. Apart from the users, other fisher folks of the region also indicated interest in adopting the INCOIS services after prior knowledge through training and awareness programmes during the surveys. ITKs used in the region are said to be obtained through inter-generational experiences and observations from others and the level of utility of ITKS were mentioned to be relatively declining except for the usage of fish catch predictions.

Goa

About 50 non-users from the North Goa district of Goa were surveyed. The fisher folks of the coastline are involved in the motorized fishing sector and dominantly use gill-netters for daily fishing activities. These respondents are unaware of the services and are keen to acquire knowledge about the scientific forecast services and dissemination. Storm surge warnings and climate/ weather forecast predictions are the service provided and are utilized in a higher rate on a weekly basis. As on today, the weather and monsoon predictions from IMD Bulletins were informed to them by the regional fisheries department via local television channels and announcements. The respondents highly rely on their indigenous practices for fishing and predicting natural calamities through several ecological indicators.

Natural Disaster: Gaja, its prevalence and socio-economic impacts off the Tamil Nadu coastline

An assessment was done on the hazards of Gaja – a very severe cyclonic storm that battered thousands of lives in Cauvery delta regions of Tamil Nadu. The study was focused on the impact assessments of the cyclone with reference to three different attributes: socio-economic factors, physical conditions and disaster preparedness and mitigation actions. Primary datasets on variables such as household, income, education, extent of damage and relief measures were collected from the family heads, community leaders and fisher-cooperative society members.

The statistical chi-square distribution was calculated to substantiate the significant relationships between the physical attributes, socio-economic conditions and level of vulnerability to the coastal communities affected by the cyclone. The major findings of the study reveal that the human vulnerability is highly significant to the physical attributes and socio-economic factors such as distance of house-holds from the shore-line, house type, income and education. Assessments on different factors summarizes that the socio-economic conditions and physical attributes of the village amplified the vulnerability of cyclone in the household level. The attributes such as geo-morphology of the village, type of houses and distance of house from the sea-shore are known to be the severe susceptible conditions for exposure and external shock to the cyclones/storm-surges. Therefore the study recommends that the disaster preparedness plans, policies and recommendations from government and non-government agencies should pay attention to these diverse attributes for effective conservation and sustainable management.

INCOIS Users / stakeholders Conclave

INCOIS 6th User Interaction meeting was well attended with the experienced fishers of Andhra Pradesh, Orissa, Kerala, Maharashtra, Tamil Nadu and Pondicherry, Technocrats, academicians and policy planners of India. The stakeholders meet was organised as part of the World Ocean Science Congress 25-27 February 2019 at Andhra Pradesh University, Vishakhapatnam. The programme was funded by Indian Council of Agriculture Research and was moderated by Dr Shyam S. Salim, Principal Investigator of the project.

The specific recommendations emanated from the meet which requires considerable attention includes:

- There is a need to provide multi-day forecast of waves, wind and tidal alerts prediction in advance, considering the change in the fishing operations on account of fishing ground and escalating costs. Cyclone warnings and high wave alerts are to be provided at least 10 days in advance. Early warning systems are mostly requested.

- Primary stakeholders' viz., the fishers are to be included in the development of any initiatives. Therefore regional / location specific local interaction meetings to be held frequently involving the fishers and local self-government in addition to all the other stakeholders.

- The need of the day is to integrate the indigenous traditional knowledge of fishermen on weather

Relief measures provided by the State Government

Coastal villages surveyed	Relief amount received (in ₹)	House construction (in₹)	Livestock (in₹)
Vellapallam	150,000	10,000	NP
Vanavanmahadevi	150,000	5,000	NP
Pushpavanam	150,000	5,000	NP
TherkuVizhunthamavadi	150,000	NP	NP
Seruthur	NP	5,000	NP
Kameswaram	15,000	NP	4,000

*NP–Not provided on account of minimal damage/ loss

and climate forecasts with the scientific information to provide improved predictions and forecast systems. The same can be validated and extended across other regions.

- The dissemination of the ocean disasters and weather predictions in real time is to be ensured considering the socio-economic profile for improved effectiveness and efficacy.
- The Government should extend appropriate and timely financial support in purchasing safety related gadgets, and towards building up the infrastructure and compensation for the loss in inventory and live losses
- There is a need to decentralize the disaster management plans and programmes with the initiation of local level planning committees / groups (local self-governing bodies) to expand the reach of Ocean Advisory Services to the stakeholders.
- Alternative livelihood options to be made available (such as developing value added products and mariculture activities) and necessary training and technologies to be provided.
- Fishermen's health related issues are also to be taken into consideration like tracking of microbial diseases and their spread in the region
- The International border alert systems are to be developed and made available to the fishermen.
- PFZ advisories within 40 kms distance from coast to be made available for the artisanal fishermen across coastal states.
- The alternate dissemination sources are to be identified across different states for e.g., information dissemination through FM Channels could be explored.

Agricultural Technology Information Centre (ATIC)

In 2019, ATIC entertained 5608 students and 1377 entrepreneurs as visitors comprising a total of 6985.

ATIC generated a revenue of ₹7,05,985/- though the sale of products (₹5,92,785/W-), diagnostic services (₹29,580/-) and through visitors' fee (₹83,620/-) shown in Tables below.

Exhibitions organized

ATIC organized 5 exhibitions during the year 2019 in various locations as follows:

Consultation Meeting on Biodiversity Beyond National Jurisdiction organised by CMLRE, Kochi organised at Holiday Inn, Kochi on 1stand 2nd July, 2019 at Hotel Holiday Inn, Kochi.

Centenary Celebration of Service Co-operative Bank, Palluruthy, Kochi during the period from 7th to 11th September, 2019.

Friends Forum, Ernakulam at Jama' ath Auditorium, Edappally, Kochi on 6th November, 2019.

Swasraya Bharath: Indian Science Congress Expo 2020 from 23rd to 26th November, 2019 at Marie Drive, Kochi.

AQUABE 2019 organised by KUFOS, Kochi during the period from 28th to 30th November, 2019at Le Meridian Hotel, Maradu, Kochi.

Training programmes organized in ATIC during 2019

Details of revenue generation in ATIC in 2019

Products	Amount
Fish feed	560747
Posters	14400
Zooplankton	4000
Clownfish	6100
Moina	500
Phytoplankton	1274.4
Key chain	50
Fish sales and others	5714
Sub-total Products	592785
Services	
Bacteriological profiling of feed	3000
Feed analysis	2000
Disease diagnosis of aquatic animal	8180
Species identification	4000
Biochemical analysis of fish meal sample	10000
Water and sediment analysis	2400
Sub-total Service Charges	29,580
Visitors' fee	83,620
Grand total	7,05,985

Revenue generation in ATIC in 2019

Items	Amount
Sale of Products	592785
Diagnostic Services	29580
Visitors' fee	83620
Total	7,05,985

ATIC organized 10 days 'On the job training programme' for VHSE Schools, Narakkal and Arthungal, on "Advances in Fisheries and Aquaculture techniques" during the period from 18th September to 1st October, 2019 for 59 students.

ATIC organised 10 days 'On the Job Training Programme for VHSE Schools, Kadamakkudy and Kaypamanagalam on "Recent Technological Advances in Aquaculture during the period from 23rd October to 2nd November, 2019 for 56 students.

1. Ten days on the job training of VHSE students
2. Winners of fish identification quiz programme conducted in ATIC

Institute Technology Management Unit

Cadalmin™ AHe from seaweeds is released by The Director-General, Indian Council of Agricultural Research, Dr. Trilochan Mohapatra on 28th May 2019

Functions of ITMU in the Institute

The ITMU of Central Marine Fisheries Research Institute functions according to the ICAR IP guidelines

- IP protection, maintenance, and management.
- To carry out an internal examination before filing patents.
- Patent filing; invite expert opinion from patent attorney/ IPR expert.
- ITMC duly records the reasons for the acceptance/rejection of each patent proposal.
- Correction/ rectification/ updation of primary information.
- Technology transfer/ commercialization.

Release and out-licensing of the CMFRI products

Cadalmin™ Antihypertensive extract (Cadalmin™ AHe) from seaweeds

Cadalmin™ Antihypertensive extract (Cadalmin™ AHe) contains 100% natural marine bioactive ingredients from selected seaweeds to combat the pathophysiologies related to hypertension. The active principles of Cadalmin™ Antihypertensive extract from seaweeds effectively inhibit various mediators, which are responsible to cause hypertension through various metabolic pathways. The bioactive ingredients in the nutraceutical product effectively decrease the serum level of oxidative stress marker nitric oxide, lipid peroxidase and the potent vasoconstrictor angiotensin-II.

Cadalmin™ AHe

Technology is scheduled to be licensed to an identified pharmaceutical company (₹11,67,000/- revenue on 5% royalty along with two other products-Cadalmin™ GAe and Cadalmin™ ADe).

Patents granted

The following patents at the Indian patent Office (including attending the hearing) for the final grant were processed.

- A device for breeding and culturing marine fish in open sea (Patent Grant number 322166; 31/CHE/2010-Indian patent)
- A method and composition for land-based culturing of pearl oyster in marine body and device, therefore (Patent Grant number 317443; 1543/CHE/2009-Indian patent)
- A process to isolate anti-inflammatory principles from green mussel *Perna viridis* to prepare a stabilized nutraceutical supplement against inflammatory disorders and a product thereof (5198/CHE/2012–Indian patent application)-Grant order under Section 43 due
- Anti-inflammatory principles in a preparation of brown seaweeds (Patent Grant number 333392; 4254/DEL/2015-Indian patent)

CMFRI product trademark–Cadalmin™ (Renewed up to 2028)

Preparation and filing of Form TM-R for renewal of registered trademark numbers 1833767 and 1833768 (Classes under 31 and 35). Date of filing of Form TM-R 03-06-2019

Registration No: 1833767 (Class 31)

Registration No: 1833768 (Class 35)

The response towards the FER/Hearing filed for the grant

Replied to objections for hearing of the patent application titled "A device and process to separate oyster meat from shell using pressurized steam" (2281/CHE/2013)-scheduled to be heard on 30-3-2020.

Response towards the FER with regard to the patent application entitled "A process to prepare anti-dyslipidemic concentrate from seaweed and a product therof" (Application No 201711013741 (Indian patent application)

Prepared the Form-III for seeking approval of National Biodiversity Authority and responded to the queries raised by NBA with the patent applications submitted.

Hearing attended towards grant

A device for breeding and culturing marine fish in open sea (31/CHE/2010): Heard on 24-9-2019; Granted on 31-12-2019

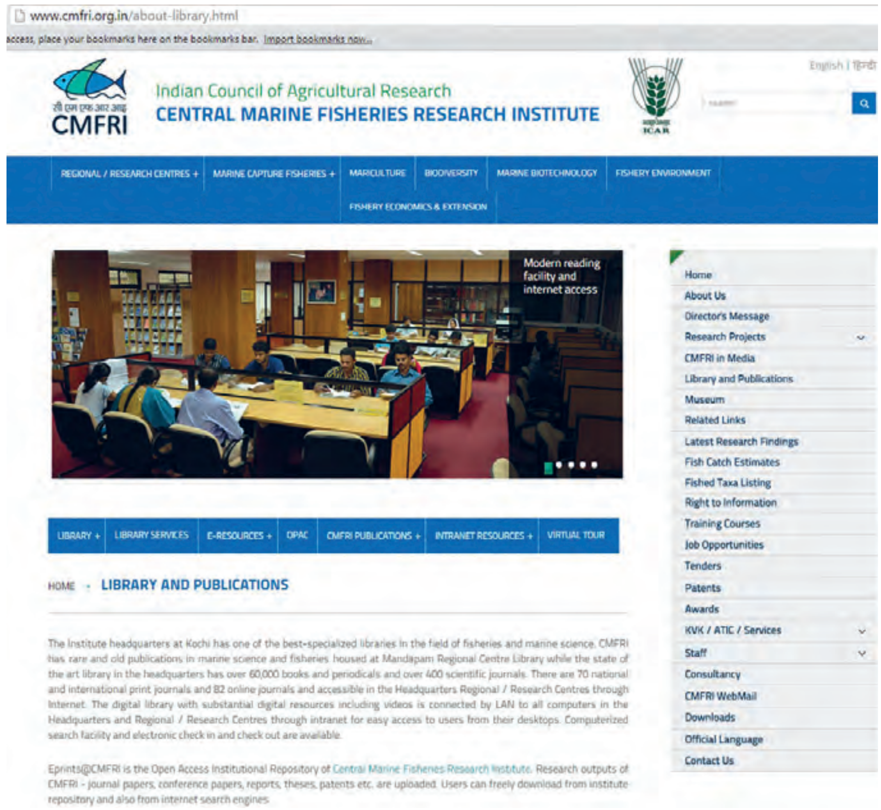
Anti-inflammatory principles in a preparation of brown seaweeds (4254/DEL/2015): Heard on 24.09.2019; Granted on 11-11-2019

A method and composition for land-based culturing of pearl oyster in a marine body and device therefore (1543/CHE/2009): Heard on 04.04.2019; Granted on 01-08-2019

A process to isolate anti-inflammatory principles from green mussel *Perna viridis* (5198/CHE/2012): Heard on 24.09.2019; Grant order under Section 43 due

Library and Documentation Centre

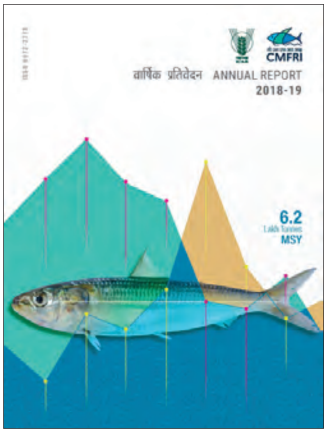
The Library pledges support for the research by the acquisition and organization of information resources, in a variety of formats in the marine fisheries sector

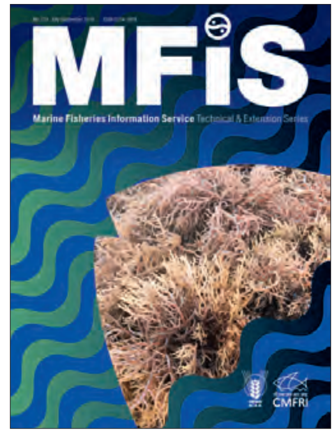


Library and Documentation Centre of CMFRI is a welcoming and beautiful study and reading space housing an impressive collection of books, journals and other information materials in marine sciences and allied areas catering to the research needs of a large community in this field. The collection at the L & D Centre reflects the mission and goals of this premier institute in the area of marine fisheries.

Our collection includes journals from 1947, more than 16500 books, more than 200 theses, dissertations, CDs, reports, proceedings, conference volumes, monographs, expedition and cruise reports, encyclopaedias, atlases, navigation charts, posters, miscellaneous publications etc. which covers vast subjects such as marine sciences, oceanography, fisheries, nautical sciences, marine biology, ecology, environmental sciences, biochemistry, genetics, biotechnology etc.

The Library pledges support for the research by the acquisition and organization of information resources, in a variety of formats to be utilized by both Internal and External library users, who have an interest in the marine fisheries sector.





It plays an important role in the research activities of the Institute by providing literature and services to the staff at HQ as well as RCs. students and researchers from Universities, Colleges, State Fisheries Departments, and other Institutions utilise CMFRI library for their academic and research purposes. CMFRI Library is a participant organisation in the National Digital Library of India. We are a content partner of ASFA and J-Gate.

Digital Library

The digital library of CMFRI named "Library and Publication" is hosted in the Institute website to extend the digital services. All digital services are accessible at HQ as well as RCs. The Library Catalogue, OPAC can be accessed globally for searching the documents available in the library. 78 subscribed online journals and 252 open access journals on fisheries and allied subjects are accessible. CeRA subscribed e-journals are made available through J-Gate platform. Access to 1174 e-books on agriculture and allied subjects and more than 3,500 e- journals are available through CeRA. 80 e-books on fish and fisheries, 17 e-book series and e-journals on fish and fisheries published by Elsevier, Wiley, Springer, Taylor & Francis are accessible at HQ and RCs.

Online Databases

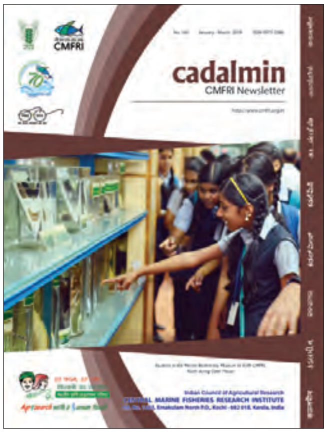
The CMFRI Library subscribes to two online databases. 'MarinLit' and 'IndiaAgristat.com' which are; Aquatic Sciences and Fisheries Abstracts (ASFA) published by Food and Agriculture Organization (FAO) was freely arranged through an information sharing programme during this year. Access to these databases is limited to the CMFRI users within the CMFRI campuses at Headquarters and RCs.

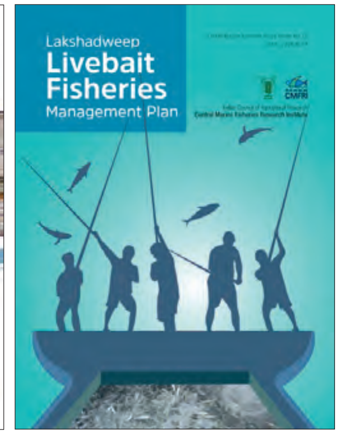
Institutional Repository 'eprints@ cmfri'

'eprints@cmfri' is the open access Institutional repository developed and hosted in the Institute website for archiving the Intellectual products created by CMFRI. Institutional Repository has a total collection of more than 13000 publications now.

DSpace@CMFRI

"DSpace@CMFRI" is the digital archive of CMFRI developed for archiving rare and old publications from the year 1800s available in CMFRI. Six thousand old and rare documents like Memoirs, Catalogues, Reports and Expedition





Reports are archived in "DSpace@ CMFRI". The documents can be searched by Author, Subject, Keyword and Year of publication. Full text of the documents can be accessed at HQ and RCs of CMFRI.

Online Library Information Service

Online Information on release of new Institute publications, activation of online databases and journals, new books purchased etc. were sent regularly to scientists and researchers in HQ and RCs by email.

Newspaper clippings

News clippings on fisheries, aquaculture and related subjects published in various newspapers were collected and compiled on monthly basis as News Clippings magazine for reference.

Online Document Delivery Service

Online Document Delivery Service is a successful service being provided through CMFRI Library. Students and scholars from universities and research institutions recognized by ICAR are the users of this service. They can make requests to the electronic copy of journal articles available at the CMFRI Library through DDR platform and they are delivered within days to them.

Scanning and Digitisation

Library has a high quality digital scanner for in house scanning and digitisation of damaged old documents. Old dissertations and books were scanned, digitised and added to repositories during the period.

Plagiarism Checking

Library makes arrangements for checking plagiarism for scientific articles of the institute staff for publishing in various journals. 'Turnitin' software was procured this year for the anti-plagiarism service.

Institute Publications

Library is entrusted with arrangements for printing, stock maintenance, distribution and sale of Institute publications. Printing arrangements made for Institute publications during the period and ISBN, ISSN and Series Nos. were allotted. The digital versions of Institute publications were uploaded in the Institute website.

Indian Journal of Fisheries

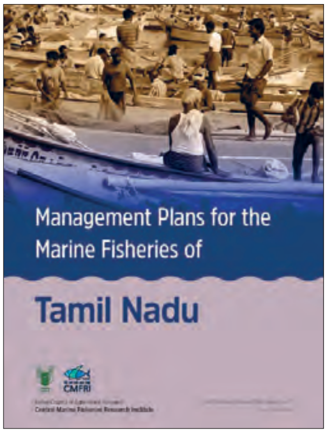
During the year, 3 issues of IJF Vol. 66 were published. Worldwide usage statistics of IJF for the year shows a total of 6232 users and 3681 users were from India. Indian Journal of Fisheries got NAAS rating 6.28.

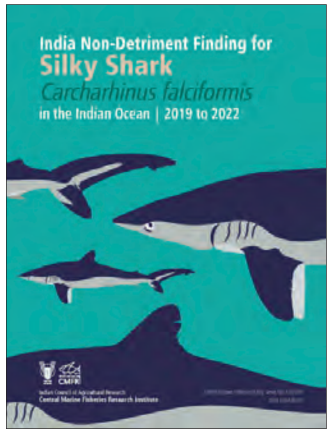
Exchange of Publications

Library maintains exchange relationship with various National and International Research Institutes, Universities and other organisations. Mailing lists are maintained for free distribution of Institute publications.

CMFRI Publications released during 2019-20

- CMFRI Annual Report 2018-2019
- Cadalmin–CMFRI Newsletter No.158, 159, 160 (English)





- Cadalmin–CMFRI Newsletter No. 155, 156, 157 (Hindi)
- Marine Fisheries Information Service No.235, 236, 237
- Marine Fish Landings in India 2018
- Indian Journal of Fisheries Vol. 66 (1-4)
- Marine Fisheries Policy Series (11): Management Plans for the Marine Fisheries of Tamil Nadu.
- Marine Fisheries Policy Series (12): Lakshadweep Livebait Fisheries Management Plan.
- Marine Fisheries Policy Series (13): India Non-Detriment Finding (NDF) for silky shark, *Carcharhinus falciformis*, in the Indian Ocean
- Marine Fisheries Policy Series (14): India Non-Detriment Finding (NDF) for thresher sharks, Alopias spp., in the Indian Ocean
- Marine Fisheries Policy Series (15): Fishery Management Plan for Palk Bay Blue Swimming Crab
- CMFRI Special Publication No. 119 Stony corals, sponges and reef fishes off Enayam to Kollam, south-west coast of India.
- Carangids of Indian seas An Illustrated Pocket Guide for Field Identification.
- Age determination in fishes using hard parts: A practical handbook
- **മത്തി എന്ന മത്സ്യ സമസ്യ**

E-Publications/Manuals

- Marine Ornamental fish production– An alternative livelihood for coastal people
- Mini RAS (Recirculatory Aquaculture System) for broodstock maintenance in Marine Ornamental fish hatcheries
- Outcomes of stakeholder consultations organized at Mandapam Regional Centre of ICAR-CMFRI
- Wealth from Fish Waste A KVK Intervention on Entrepreneurial Capacity Building.
- Handbook on Marine Ornamental Fish Seed Production
- Handbook on Sea cage Farming of Cobia
- Practical Hand Book on Seed Production of Cobia and Silver Pompano
- Training Manual on Advances in Marine Fisheries in India
- Manual for Operation of Mini Secchi Disc and the Mobile App TurbAqua Developed as Part of Revival Project.
- Global Understanding and Learning for Local Solutions (GULLS) – Reducing Vulnerability of the Marine Dependent Coastal Communities
- Training Manual on Cage culture of Marine Fishes **കടൽകൂട് മത്സ്യകൃഷി പരിശീലന പുസ്തകം**
- கூண்டுகளில் கடல் விரால் மீன் வளர்ப்பு (HandBook on Sea Cage Farming of cobia)

Budget

EXPENDITURE UP TO 31.03.2020				(₹ In Lakhs)
	Name of the Head	RE 2019-20	Progressive Expenditure up to 31.03.2020	% of Utilization
	Grants for creation of Capital Assets (CAPITAL)			
1	Works			
	(A) Land	0.00	0.00	0.00
	(B) Building			
	i Office Building	101.29	101.29	100.00
	ii Residential Building	0.00	0.00	0.00
	iii Minor Works	4.20	4.20	100.00
2	Equipments	200.82	200.82	100.00
3	Information Technology	39.00	39.00	100.00
4	Library Books and Journals	20.00	20.00	100.00
5	Vehicle & Vessels	9.09	9.09	100.00
6	Livestock	0.00	0.00	0.00
7	Furniture & Fixtures	19.98	19.98	100.00
8	Others	4.90	4.90	100.00
	Total – CAPITAL (Grants for creation of Capital Assets)	399.29	399.29	100.00

Grants in Aid - Salaries (REVENUE)

1	Establishment Expenses			
	Salaries			
	i. Establishment Charges	6600.00	6600.00	100.00
	ii. Wages	0.00	0.00	0.00
	iii. Overtime Allowance	0.00	0.00	0.00
	Total – Establishment Expenses (Grant in Aid - Salaries)	6600.00	6600.00	100.00

Grants in Aid - General (REVENUE)

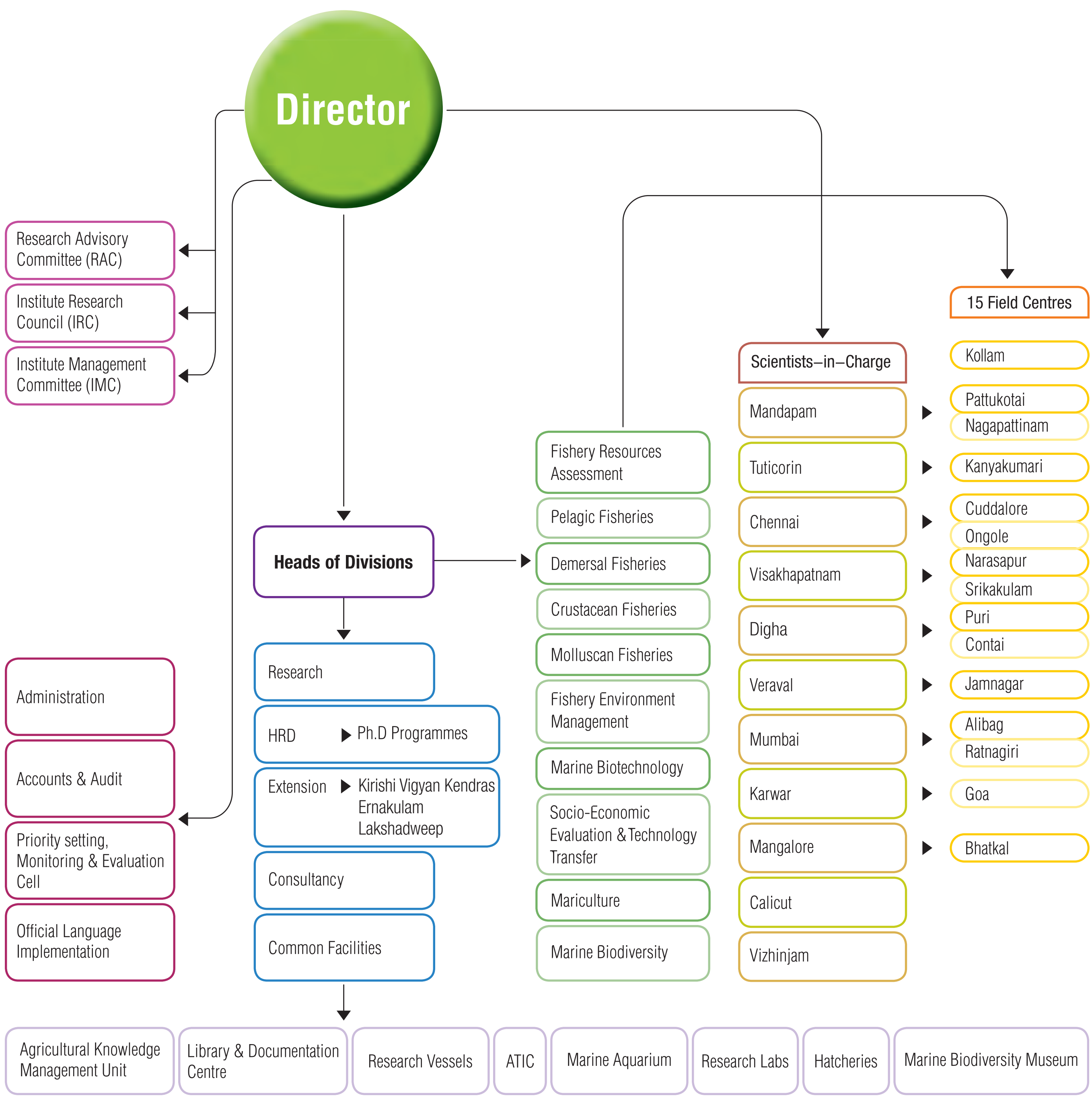
1	**Pension & Other Retirement Benefits**	**7212.00**	**7212.00**	**100.00**
2	**Travelling Allowance**			
	(A) Domestic TA/Transfer TA	216.00	216.00	100.00
	(B) Foreign TA	2.00	2.00	100.00
	Total – Traveling Allowance	218.00	218.00	100.00
3	**Research & Operational Expenses**			
	(A) Research Expenses	170.00	170.00	100.00
	(B) Operational Expenses	140.00	140.00	100.00
	Total - Research & Operational Expenses	310.00	310.00	100.00
4	**Administrative Expenses**			
	(A) Infrastructure	525.00	525.00	100.00
	(B) Communication	49.29	49.29	100.00
	(C) Repairs & Maintenance			
	i Equipments, Vehicles & Others	130.00	130.00	100.00
	ii Office Building	84.07	84.07	100.00
	iii Residential Building	9.80	9.80	100.00
	iv Minor Works	9.98	9.98	100.00
	(D) Others (excluding TA)	258.37	258.37	100.00
	Total - Administrative Expenses	1066.51	1066.51	100.00
5	**Miscellaneous Expenses**			
	A HRD	8.00	8.00	100.00
	B Other items (Fellowships, Scholorship etc.)	7.00	7.00	100.00
	C Publicity & Exhibition	12.75	12.75	100.00
	D Guest House - Maintenance	10.00	10.00	100.00
	E Other Miscellaneous	7.25	7.25	100.00
	Total - Miscellaneous Expenses	45.00	45.00	100.00
	Total Grants in Aid - General	8851.51	8851.51	100.00
	Grand Total	15850.80	15850.80	100.00
	TSP - Capital	10.00	9.99	99.86
	TSP - General	22.00	22.00	100.00
	Total TSP	32.00	31.99	99.96
	SCSP-Capital	43.32	43.32	100.00
	SCSP-General	144.23	144.23	100.00
	Total SCSP	187.55	187.55	100.00
	RE-Total	16070.35	16070.33	100.00
	Loans & Advances	15.00	14.97	99.83

		(₹ In Lakhs)
Revenue 2019-20	Target	Achieved
Income from Sales/services		69.66
Fee/Subscription	67.25	22.20
Income from Royalty, publication etc.		0.78
Total	67.25	92.64

	(₹ In Lakhs)
Other Receipts	Amount
Other Income	79.46
STD Interest	131.65
Sale of Asset	0.00
Recoveries on Loans & Advances	18.85
CPWD/Grants Refund	4.01
Total	233.97

					(₹ In lakhs)
	Opening Balance	Receipts	Expenditure	Refund	Closing Balance
AINP M	0.00	377.61	377.59	0.02	0.00
NICRA	0.37	198.93	196.94	0.00	2.36
Winter/Summer School	1.33	5.41	5.28	1.67	-0.21
Emeritus	2.48	11.60	10.58	0.00	3.50
National Disaster Relief Fund (ICAR)	0.00	201.00	201.00	0.00	0.00
National Fund Schemes	1.46	0.00	0.00	1.46	0.00
Other Schemes	14.07	95.80	91.42	1.03	17.42
KVK, Narakkal	6.99	141.38	139.51	0.00	8.86
KVK, Lakshadweep	4.21	46.23	50.24	0.00	0.20
Deposit Schemes (Externally funded)	1194.64	2044.57	1597.50	9.61	1632.10
Consultancies	657.69	203.77	142.53	0.00	718.93

Organogram


Director
Research Advisory Committee (RAC)
Institute Research Council (IRC)
Institute Management Committee (IMC)
Administration
Accounts & Audit
Priority setting, Monitoring & Evaluation Cell
Official Language Implementation
Heads of Divisions
Research
HRD
Ph.D Programmes
Extension
Kirishi Vigyan Kendras Ernakulam Lakshadweep
Consultancy
Common Facilities
Fishery Resources Assessment
Pelagic Fisheries
Demersal Fisheries
Crustacean Fisheries
Molluscan Fisheries
Fishery Environment Management
Marine Biotechnology
Socio-Economic Evaluation & Technology Transfer
Mariculture
Marine Biodiversity
Scientists–in–Charge
Mandapam
Tuticorin
Chennai
Visakhapatnam
Digha
Veraval
Mumbai
Karwar
Mangalore
Calicut
Vizhinjam
15 Field Centres
Kollam
Pattukotai
Nagapattinam
Kanyakumari
Cuddalore
Ongole
Narasapur
Srikakulam
Puri
Contai
Jamnagar
Alibag
Ratnagiri
Goa
Bhatkal
Agricultural Knowledge Management Unit
Library & Documentation Centre
Research Vessels
ATIC
Marine Aquarium
Research Labs
Hatcheries
Marine Biodiversity Museum

Personnel

Scientific

No	Name of Employee	Designation
KOCHI		
1	Dr. A. Gopalakrishnan	Director & Principal Scientist
2	Dr. K. Sunilkumar Mohammed	Principal Scientist & Head, MFD
3	Dr. P. U. Zachariah	Principal Scientist & Head, DFD
4	Dr. (Smt.) V. Kripa	Principal Scientist & Head, FEMD
5	Dr. T. V. Sathianandan	Principal Scientist & Head, FRAD
6	Dr. K. K. Joshi	Principal Scientist & Head, MBD
7	Dr. P. Vijayagopal	Principal Scientist & Head, MBTD
8	Dr. (Smt.) Imelda Joseph	Principal Scientist &Head, MCD
9	Dr. Boby Ignatius	Principal Scientist & SIC, PME Cell
10	Dr. J. Jayasankar	Principal Scientist/SIC, AKMU
11	Dr. (Smt.) Josileen Jose	Principal Scientist
12	Dr. K. Madhu	Principal Scientist
13	Dr. (Smt.) K. S. Sobhana	Principal Scientist
14	Dr. (Smt.) Shoji Joseph	Principal Scientist
15	Dr. E. M. Abdusamad	Principal Scientist
16	Dr. (Smt.) Rema Madhu	Principal Scientist
17	Dr. (Smt.) D. Prema	Principal Scientist
18	Dr. C. Ramachandran	Principal Scientist
19	Dr. (Smt.) Molly Varghese	Principal Scientist
20	Dr. (Smt.) Somy Kuriakose	Principal Scientist
21	Dr. V. P. Vipin Kumar	Principal Scientist
22	Dr. Shyam S. Salim	Principal Scientist
23	Dr. (Smt.) U. Ganga	Principal Scientist
24	Dr. (Smt.) Rekha J. Nair	Principal Scientist
25	Dr. (Smt.) S. Lakshmi Pillai	Principal Scientist
26	Dr. S. R. Krupesha Sharma	Principal Scientist
27	Dr. P. Jayasankar	Principal Scientist & former Director, CIFA, Bhubaneswar
28	Dr. (Smt.) Mini. K. G.	Principal Scientist
29	Dr. P. Kaladharan	Principal Scientist
30	Dr. (Mrs.) Reeta Jayasankar	Principal Scientist
31	Dr. T. M. Najmudeen	Principal Scientist
32	Shri. N. K. Sanil	Senior Scientist
33	Dr. (Smt.) N. Aswathy	Senior Scientist
34	Dr. R. Jeyabaskaran	Senior Scientist
35	Dr. Grinson George	Senior Scientist
36	Dr. Kajal Chakraborty	Senior Scientist
37	Dr. V. Venkatesan	Senior Scientist
38	Dr. (Smt.) Rekhadevi Chakraborty	Senior Scientist
39	Dr. Sandhya Sukumaran	Senior Scientist
40	Shri. Wilson T. Mathew	Scientist
41	Dr. Pradeep M. A.	Scientist
42	Smt. Reshma K. J.	Scientist
43	Dr. (Smt.) Vidya R.	Scientist
44	Shri. Sanal Ebeneezar	Scientist
45	Dr. Vivekanand Bharti	Scientist
46	Dr. Shinoj P.	Senior Scientist
47	Dr. (Smt.)Miriam Paul Sreeram	Senior Scientist
48	Shri. Rajesh N.	Scientist
49	Dr. (Smt.)Sumithra T. G.	Scientist

No	Name of Employee	Designation
50	Dr. Shelton Padua	Scientist
51	Dr. Livi Wilson	Scientist
52	Dr. Jeena N. S.	Scientist
53	Dr. K. Mohammed Koya	Scientist
54	Dr. Sreenath K. R.	Scientist
55	Dr. Eldho Varghese	Scientist
56	Dr.(Smt). Reshma Gills	Scientist
57	Dr. Ratheesh Kumar R.	Scientist
CALICUT RESEARCH CENTRE		
1	Dr. P. K. Asokan	Principal Scientist & SIC
2	Dr. Gulshad Mohamed	Principal Scientist
3	Dr. K. Vinod	Principal Scientist
4	Smt. Ramya Abhijith	Scientist
5	Dr. Mahesh V.	Scientist
6	Dr. Shilta M. T.	Scientist
7	Shri. K. P. Said Koya	Scientist (Selection Grade)
DIGHA RESEARCH CENTRE		
1	Dr. Gyanranjan Dash	Scientist
2	Dr. Swathipriyanka Sen Dash	Scientist
KARWAR RESEARCH CENTRE		
1	Dr. Jayasree Loka	Principal Scientist & SIC
2	Dr. T. Senthil Murugan	Senior Scientist
3	Ms. Saloni Shivam	Scientist
4	Shri. Kurva Raghu Ramudu	Scientist
5	Dr. Suresh Babu P. P.	Senior Scientist
6	Dr. Anuraj A.	Scientist
KVK of CMFRI		
1	Dr. Shinoj Subramannian	Sr. Scientist & PC
MADRAS RESEARCH CENTRE		
1	Dr. P. Laxmilatha	Principal Scientist & SIC
2	Dr. R. Narayanakumar	Principal Scientist & Head, SEETTD
3	Dr. Joe K. Kizhakudan	Principal Scientist
4	Dr. (Smt.) Sobha Joe Kizhakudan	Principal Scientist
5	Dr. (Smt.) P. T. Sarada	Principal Scientist
6	Dr. A. K. Abdul Nazar	Principal Scientist
7	Dr. (Ms.) A. Margaret Muthu Rathinam	Principal Scientist
8	Dr. Srinivasa Raghavan V.	Scientist
9	Dr. E. M. Chhandaprajnadarsini	Scientist
10	Ms. Saima Rehman	Scientist
11	Shri. Adnan Hussain Gora	Scientist

No	Name of Employee	Designation
MANDAPAM REGIONAL CENTRE		
1	Dr. Rengarajan Jayakumar	Principal Scientist & SIC
2	Dr. G. Tamilmani	Senior Scientist
3	Dr. M. Sakthivel	Senior Scientist
4	Shri. S. Thirumalaiselvan	Scientist
5	Shri. Vinothkumar R.	Scientist
6	Shri. Sankar M.	Scientist
7	Dr. Johnson B.	Scientist
8	Dr. P. Rameshkumar	Scientist
9	Dr. Saravanan R.	Scientist
10	Dr. Anikuttan K. K.	Scientist
11	Shri. S. Chandrasekar	Scientist
12	Ms. Remya L.	Scientist
13	Shri. Rajkumar M.	Scientist
MANGALORE RESEARCH CENTRE		
1	Dr. Prathibha Rohit	Principal Scientist, SIC & Head, PFD
2	Dr. A. P. Dinesh Babu	Principal Scientist
3	Dr. Sujitha Thomas	Principal Scientist
4	Dr. (Smt.) Geetha Sasikumar	Principal Scientist
5	Dr. K. M. Rajesh	Principal Scientist
6	Dr. (Smt.) Bindu Sulochanan	Senior Scientist
7	Dr. Divya Viswambharan	Scientist
8	Dr. Purushottama G. B.	Scientist
MUMBAI RESEARCH CENTRE		
1	Dr. Anulekshmi Chellappan	Scientist & SIC
2	Shri. Bhendekar Santosh Nagnath	Scientist
3	Dr. S. Ramkumar	Scientist
4	Dr. Akhilesh K. V.	Scientist
5	Shri. Nakhawa Ajay Dayaram	Scientist
PURI FIELD CENTRE		
1	Dr. Subal Kumar Roul	SIC
2	Shri. Rajesh Kumar Pradhan	Scientist
TUTICORIN RESEARCH CENTRE		
1	Dr. P. P. Manoj Kumar	Principal Scientist & SIC
2	Dr. I. Jagadis	Principal Scientist
3	Dr. (Smt.) Asha P. S.	Principal Scientist
4	Dr. (Mrs.) C. P. Suja	Principal Scientist
5	Dr. C Kalidas	Scientist
6	Dr. L. Ranjith	Scientist
7	Ms. Kavitha M.	Scientist
8	Shri. Linga Prabhu D.	Scientist

No	Name of Employee	Designation
VERAVAL REGIONAL CENTRE		
1	Dr. Divu Damodaran	Scientist & SIC
2	Shri. Abdul Azeez P.	Scientist
3	Shri. Tarachand Kumawat	Scientist
4	Shri. Sukhdhane Kapil Sukhadeo	Scientist
5	Shri. Vinaya Kumar Vase	Scientist
6	Shri. Rajan Kumar	Scientist
7	Smt. Shikha Rahandgale	Scientist
VISAKHAPATNAM REGIONAL CENTRE		
1	Dr. Shubhadeep Ghosh	Principal Scientist & SIC
2	Dr. S. Sathyanarayana Raju	Principal Scientist
3	Dr. Ritesh Ranjan	Senior Scientist
4	Dr. Indira Divipala	Scientist
5	Dr. Biji Xavier	Scientist

No	Name of Employee	Designation
6	Dr. Muktha M.	Scientist
7	Dr. Loveson Edward L.	Scientist
8	Dr. Pralaya Ranjan Behera	Scientist
9	Dr. Sekar Megarajan	Scientist
10	Dr. Jasmin F.	Scientist
11	Dr. Manas H. M.	Scientist
VIZHINJAM RESEARCH CENTRE		
1	Dr. M. K. Anil	Principal Scientist & SIC
2	Dr. P. S. Swathilekshmi	Principal Scientist
3	Dr. B. Santhosh	Principal Scientist
4	Dr. Jasmine S.	Principal Scientist
5	Dr. Smt. K. N. Saleela	Senior Scientist
6	Dr. Surya S.	Scientist
7	Shri. Ambarish P Gop	Scientist
8	Ms. P. Gomathi	Scientist

Dr. Wazir Singh Lakra

NABARD Chair Professor

Former Director/Vice-Chancellor, ICAR-CIFE, Mumbai has joined as NABARD Chair Professor at Mumbai RC of CMFRI from 10.10.2019 for a period of five years. His area of research would be "Management of Marine Fisheries and Sustainable Livelihood of traditional fisherman in Maharashtra".

Technical

No	Name of Employee	Designation
ALIBAG FIELD CENTRE		
1	Shri. Sonara Yogesh Zinabhai	Technician
BHATKAL FIELD CENTRE		
1	Shri. Udaya V. Arghekar	Technical Officer
2	Shri. Ganesh Bhatkal	Technical Officer
CALICUT RESEARCH CENTRE		
1	Shri. V. A. Kunhikoya	Assistant Chief Technical Officer
2	Shri. N. P. Ramachandran	Senior Technical Assistant
3	Shri. C. Chandran	Senior Technical Assistant
4	Smt. P. Renuka	Senior Technician
5	Shri. Ansar Pokkarakath	Technician
6	Ms. Silpa P. G.	Technician
7	Shri. T. Rajesh Babu	Technician
DIGHA RESEARCH CENTRE		
1	Shri. Swapan Kumar Kar	Technical Officer
2	Shri. Indranil Mukherjee	Technician

No	Name of Employee	Designation
CUDDALORE. FIELD CENTRE		
1	Shri. S. Pradeep	Senior Technician
2	Shri. Vishnu P. G.	Technician
JAMNAGAR FIELD CENTRE		
1	Shri. Makadia B. V.	Technical Officer
2	Shri. Makwana Somapitha	Senior Technician
KANNUR, DATA COLLECTING POINT		
1	Shri. Shiju P.	Sr. Technician
KANYAKUMARI FIELD CENTRE		
1	Shri. P. Rajendran	Sr. Technician
KARWAR RESEARCH CENTRE		
1	Shri. Narayan G. Vaidya	Senior Technical Officer
2	Ms. Sonali S. Mhaddolkar	Senior Technical Assistant
3	Shri. Kodi Srinivasa Rao	Senior Technical Assistant
4	Dr. Praveen Narayan Dube	Technical Assistant
5	Shri. N. Selvakumar	Senior Technician
6	Smt. Pramila Harish Borkar	Senior Technician

No	Name of Employee	Designation
KOCHI		
1	Shri. P. S. Anilkumar	ACTO
2	Smt. G. Shylaja	ACTO
3	Shri. N. Viswanathan	Chief Technical Officer (Civil)
4	Smt. E. K. Uma	Chief Technical Officer (Hindi Translator)
5	Smt. K. Ramani	ACTO
6	Shri. N. K. Harshan	Senior Technical Assistant
7	Shri. P. S. Alloycious	Senior Technical Assistant
8	Shri. K. C. Hezhakiel	Senior Technical Assistant
9	Smt. Jenni B.	Senior Technical Officer
10	Shri. Sijo Paul	Senior Technical Officer
11	Smt. K. P. Salini	Senior Technical Officer
12	Smt. P. K. Seetha	Senior Technical Officer
13	Dr. M. P. Paulton	Assistant Chief Technical Officer (Trg.)
14	Shri. K. N. Pushkaran	Technical Officer
15	Shri. V. K. Manu	Technical Officer (Programm Assistant-Computer)
16	Shri. P. K. Baby	Technical Officer
17	Shri. K. G. Baby	Technical Officer
18	Smt. Sindhu K. Augustine	Technical Officer
19	Shri. A. Padmanabha	Technical Officer (Electrical)
20	Shri. K. G. Radhakrishnan Nair	Technical officer (Motor Driver)
21	Smt. Dipti N. V.	Technical Officer (Programme Assistant - Laboratory Technician)
22	Shri. Arun Surendran P. S.	Senior Technical Assistant
23	Smt. Lavanya S.	Senior Technical Assistant
24	Shri. K. Solaman	Senior Technical Assistant
25	Shri. Manjeesh R.	Technical Assistant (Computer Application)
26	Shri. M. N. Sathyan	Technial Assistant (Motor Driver)
27	Smt. Sajeela K. A.	Technical Assistant
28	Shri. Sajikumar K. K.	Technical Assistant
29	Shri. Retheesh T. B.	Technical Assistant
30	Smt. Anusree V. Nair	Technical Assistant
31	Shri. Binoy Bhaskaran	Technical Assistant
32	Shri. Ragesh N.	Technical Assistant
33	Shri. Sayooj P.	Technical Assistant
34	Shri. Aju. K. Raju	Technical Assistant
35	Smt. Reena V Joseph	Technical Assistant
36	Shri. K. M. David	Technical Assistant (Artist)
37	Shri. C. V. Jayakumar	Technical Assistant (Press & Editorial)
38	Smt. Vandanaa V.	Technical Assistant (Hindi Translator)
39	Shri. P. R. Abhilash	Technical Assistant (Exb. Asst)
40	Shri. M. Radhakrishnan	Senior Technician

No	Name of Employee	Designation
41	Smt. Dhanya G.	Senior Technician
42	Shri. David Babu	Senior Technician
43	Shri. M. P. Mohandas	Senior Technician
44	Shri. V. H. Venu	Senior Technician
45	Smt. J. Sudhadevi	Senior Technician
46	Smt. Shyamala M. P.	Senior Technician
47	Shri. P. V. Sunil	Senior Technician
48	Shri. Shaji A. K.	Senior Technician
49	Smt. Sheela P. P.	Senior Technician
50	Shri. Jestin Joy. K. M.	Senior Technician
51	Shri. Sreekumar K. M.	Technician
52	Shri. Vijayan M. T.	Technician
53	Shri. Kishor T. G.	Technician
54	Shri. Sreesanth L.	Technician
55	Shri. Sunil K. T. S.	Technician
56	Shri. Jishnudev M. A.	Technician
57	Smt. S. Prasannakumari	Technician
58	Shri. Abbas A. Mohammed	Technician (On temporary transfer)
59	Shri. Anoob P. Anassery	Technician
KOVALAM FIELD LAB.		
1	Shri. R. Ponniah	Technical Officer (Electrical)
2	Shri. M. Anbarasu	Sr. Technical Assistant
3	Smt. I. Santhosi	Senior Technician
KVK, Narakkal		
1	Smt. P. Sreelatha	Chief Technical Officer
2	Shri. F. Pushparaj Anjelo	ACTO (SMS- Agricultural Extension)
3	Dr. Karikkathil Smitha Sivadasan	ACTO (SMS- Animal Husbandry)
4	Shri. Shoji Joy Edison	ACTO (SMS- Horticulture)
5	Dr. Vikas P. A.	ACTO (SMS- Fisheries)
6	Shri. Sineesh Ambi	Technician (Motor Driver)
7	Shri. Binoop C. S.	Technician (Motor Driver)
KVK, Lakshadweep		
1	Dr. Abdul Gafoor V. M.	Senior Technical Officer (SMS-Poultry& Animal Science)
2	Shri. A. Anasukoya	Technical Officer
MADRAS RESEARCH CENTRE		
1	Shri. S. Mohan	Assistant Chief Technical Officer
2	Shri. D. Pugazhendi	Assistant Chief Technical Officer
3	Shri. K. Diwakar	Assistant Chief Technical Officer
4	Shri. P. Jaiganesh	Technical Officer
5	Smt. S. Gomathy	Senior Technical Officer
6	Shri. N. Rudhramurthy	Senior Technical Officer

No	Name of Employee	Designation
7	Shri. K. S. Shiak Mohamed Yousuf	Senior Technical Assistant
8	Shri. S. Selvanidhi	Senior Technical Assistant
9	Shri. R. Vasu	Senior Technician
10	Shri. R. Sunder	Senior Technician
11	Shri. V. Joseph Xavier	Senior Technician
12	Shri. Bareen Mohamed	Senior Technician
13	Shri. V. Sitaramacharyulu	Technician
14	Smt. Sini M. B.	Technician
15	Shri. J. Balaji	Technician
MANDAPAM REGIONAL CENTRE		
1	Dr. V. Mohan	ACTO (Library)
2	Shri. I. Mendonza Xavier	ACTO (Draughtsman)
3	Shri. S. Sekar V. Rayer	Technical Officer (Skin Diver)
4	Shri. A. Vairamani	Technical Officer
5	Shri. A. Gandhi	Technical Officer
6	Shri. G. Hanumantha Rao	Senior Technical Assistant
7	Shri. M. Asokan	Senior Technical Assistant (Painter-cum-Polisher)
8	Smt. Priya K. M.	Technical Assistant (Hindi Translator)
9	Shri. Vijaya Karthikeyan	Technical Assistant (Electrician)
10	Shri. M. Palanichamy	Senior Technician (Electrician)
11	Shri. K. Shanmughanathan	Senior Technician
12	Shri. M. Jayasingh	Techincian
13	Shri. S. Murugaboopathy	Senior Technician
14	Shri. N. Ramakrishnan	Senior Technician
15	Shri. I. Syed Sadiq	Senior Technician
16	Shri. V. Muniasamy	Senior Technician
17	Shri. B. Kathiresan	Technician
18	Shri. K. Muniyasamy	Technician
19	Shri. M. Ganesan	Technician
20	Shri. M. Thayalan	Technician
21	Shri. K. Senthil Kumar	Technician
22	Shri. Tinto Thomas	Technician
MANGALORE RESEARCH CENTRE		
1	Shri. V. Lingappa	Technical Officer
2	Dr. Veena Shettigar	Technical Officer
3	Shri. U. Jeyaram	Technical Officer
4	Shri. C. G. Ulvekar	Senior Technical Assistant
5	Shri. M. Chaniappa	Technical Officer
6	Shri. G. D. Nataraja	Technical Officer
7	Shri. P. Harshakumar	Senior Technical Assistant (Motor Driver)
8	Shri. Karamathullah Sahib P.	Senior Technician

No	Name of Employee	Designation
MUMBAI RESEARCH CENTRE		
1	Shri. Nilesh Anil Pawar	ACTO
2	Shri. Thakurdas	Technical Officer
3	Shri. Jayadev S. Hotagi	Technical Officer
4	Shri. Baban N. Katkar	Technical Officer
5	Shri. Bashir Ahmed Adam Shilodar	Technical Officer
6	Shri. Suresh Krishnaro Kamble	Senior Technical Assistant
7	Shri. Sashikant R. Yadav	Senior Technical Assistant (Motor Driver)
8	Shri. Punam Ashok Khandagle	Senior Technical Assistant
9	Shri. Vaibhav Dinkar Mhatre	Senior Technical Assistant
10	Shri. Umesh Hari Rane	Technical Assistant
11	Shri. M. P. Jadhav	Senior Technician
12	Shri. Bhangare Sunil Ramachandra	Technician
13	Shri. Digambar Suresh Kumbhar	Technician
NAGAPATTINAM FIELD CENTRE		
1	Shri. A. Ramesh	Technician
NARSAPUR FIELD CENTRE		
1	Shri. Panchakarla Nagaraju	Technician
GOA FIELD CENTRE		
1	Shri. Mahendra Pandit Sonawane	Technician
ONGOLE FIELD CENTRE		
1	Shri. S. V. Subba Rao	Senior Technical Assistant
2	Shri. G. Sudhakar	Technical Officer
PATTUKOTTAI FIELD CENTRE		
1	Shri. A. Kumar	ACTO
2	Shri. S. M. Sikkender Batcha	Senior Technician
PURI FIELD CENTRE		
1	Shri. M. Kala Mallik	Technician
2	Dr. Biswajit Dash	Assistant Chief Technical Officer
3	Dr. Madhumita Das	Assistant Chief Technical Officer
4	Shri. Prakash Chandra Das	Technician
5	Ms. Menaka Das	Technician
QUILON FIELD CENTRE		
1	Shri. Paulose Jacob Peter	Technician
2	Shri. Ratheesh T.	Senior Technical Assistant
RATNAGIRI FIELD CENTRE		
1	Shri. D. D. Sawant	Technical Officer
2	Shri. Shrikrishna Pandurang Hotekar	Technician

No	Name of Employee	Designation
SRIKAKULAM FIELD CENTRE		
1	Shri. Y. V. S. Suryanarayana	Senior Technical Assistant
2	Shri. Ashok Maharshi	Senior Technical Assistant
TUTICORIN RESEARCH CENTRE		
1	Shri. S. Mohamed Sathakathullah	Technical Officer
2	Shri. N. Jesuraj	Technical Officer (Skin Diver)
3	Shri. P. Muthukrishnan	Technical Officer (Skin Diver)
4	Shri. K. P. Kanthan	Technical Assistant
5	Shri. K. Ramaswamy	Technical Assistant (Motor Driver)
6	Shri. K. Murugan	Senior Technician
7	Shri. S. Willington	Technician
8	Ms. Sruthi N. S.	Technician
9	Shri. N. Ramaswamy	Technician
VERAVAL REGIONAL CENTRE		
1	Shri. Suresh Kumar Mojjada	ACTO
2	Shri. Fofandi Mahendra Kumar	ACTO
3	Shri. Polara Jamnadas Premji	Technical Officer
4	Shri. Ladani Amrutlal Arjunbhai	Technical Officer
5	Shri. Chudasama Ramji Raja	Senior Technical Assistant
6	Shri. H. M. Bhint	Technical Assistant
7	Shri. Solanki Vipulkumar Mulajibhai	Technician
8	Ms. Gohel Jayshree Khimji	Technician
9	Shri. Chudasama Karsan Punja	Technician
10	Shri. Bhatt Bhargav Hareshbhai	Technician

No	Name of Employee	Designation
VISAKHAPATNAM REGIONAL CENTRE		
1	Dr. Phalguni Pattnaik	Assistant Chief Technical Officer
2	Shri. R. V. D. Prabhakar	Technical Officer
3	Shri. T. Nageswara Rao	Technical Officer
4	Shri. K. Gouri Sankara Rao	Technical Officer (Computer)
5	Shri. P. Venkataramana	Technical Officer
6	Shri. Ravi Kumar Avadhanula	Technical Assistant
7	Shri. Narsimhulu Sadhu	Senior Technical Assistant
8	Shri. Mamidi Satishkumar	Senior Technical Assistant
9	Shri. Balla Vamsi	Technical Assistant
10	Shri. Chinni Babu Bathina	Technical Assistant
11	Shri. Suresh Kumar Pilli	Technical Assistant
12	Shri. R. P. Venkatesh	Senior Technician (Fitter)
13	Smt. Sangaru Padmaja Rani	Senior Technician
14	Shri. Durga Suresh Relangi	Senior Technician
15	Shri. Rachakonda Shivaraju	Technician
16	Shri. D. Bhaskara Rao	Senior Technician
17	Shri. D. Jaganna	Senior Technician
18	Shri. C. H. Moshe	Senior Technician
19	Ms. Renuka K.	Technician
VIZHINJAM RESEARCH CENTRE		
1	Shri. V. A. Leslie	Senior Technical Officer
2	Shri. K. K. Suresh	Senior Technical Officer
3	Shri. Jose Kingsly	Senior Technical Officer
4	Shri. A. Udayakumar	Senior Technical Officer
5	Shri. V. P. Benziger	Technical Officer (Deckhand)
6	Shri. B. Raju	Senior Technical Assistant
7	Shri. Albert Idu K. A.	Technical Assistant

Administrative

No	Name of Employee	Designation
CALICUT RESEARCH CENTRE		
1	Shri. R. Sreenivasan	Assistant Administrative Officer
2	Smt. K. Balamani	Assistant
3	Shri. C. P. Umasankar	Upper Division Clerk
DIGHA RESEARCH CENTRE		
4	Shri. Santosh Kumar	Assistant
KARWAR RESEARCH CENTRE		
5	Shri. Ratan P. Naik	Upper Division Clerk

No	Name of Employee	Designation
6	Smt. Vijayalaxmi Y. Gamanagatti	Lower Division Clerk
KOCHI		
7	Shri. Prashant Kumar	Chief Finanace & Accounts Officer
8	Shri. Raghunadhan K.	Administrative Officer
9	Smt. N. K. Anupama	Assistant Finance&Accounts Officer
10	Smt. Sreedevi M. R.	Assistant Finance&Accounts Officer
11	Smt. Meera K. N.	Assistant Administrative Officer
12	Shri. P. V. Devassy	Assistant Administrative Officer
13	Smt. C. M. Jenny	Assistant Administrative Officer

No	Name of Employee	Designation
14	Smt. V. K. Sobha	Assistant Administrative Officer
15	Smt. Ponnamma Radhakrishnan	Assistant Administrative Officer
16	Shri. K. Ramadasan	Assistant Administrative Officer
17	Smt. Febeena P. A.	Junior Accounts Officer
18	Smt. N. G. Supriya	Assistant
19	Smt. M. Safiyabi	Assistant
20	Shri. Rishikesh Aandi	Assistant
21	Smt. Molly Lazer	Assistant
22	Smt. G. Ambika	Assistant
23	Smt. V. Jayalakshmi	Assistant
24	Smt. C. A. Leela	Assistant
25	Smt. Manjusha G. Menon	Assistant
26	Smt. Soumya Surendran	Assistant
27	Smt. Ramya M.	Assistant
28	Smt. P. K. Mary	Assistant
29	Smt. Binny Cherian	Assistant
30	Smt. Gouri Hareendran	Assistant
31	Smt. T. C. Chandrika	Assistant
32	Shri. K. S. Ajith	Assistant
33	Shri. Roshin Pushpan	Assistant
34	Smt. Sumeena N. K.	Assistant
35	Shri. Sunil A. T.	Assistant
36	Shri. Joseph Mathew	Assistant
37	Shri. D. Augustus Julin Raj	Assistant
38	Smt. Annies Mary Paulose	Assistant
39	Smt. P. Vineetha	Private Secretary
40	Shri. C. D. Manoharan	Private Secretary
41	Smt. P. K. Anitha	Private Secretary
42	Smt. Bindu Sanjeev	Private Secretary
43	Smt. K. Smitha	Personal Assistant
44	Shri. T. K. Sumesh	Upper Division Clerk
45	Shri. K. S. Sunil Raj	Assistant
46	Smt. Deepa P. N.	Upper Division Clerk
47	Smt. Manju Jose	Upper Division Clerk
48	Shri. R. Balakrishnan	Upper Division Clerk
49	Shri. E. A. Roopesh	Upper Division Clerk
50	Smt. Sujatha K. K.	Upper Division Clerk
51	Shri. S. Sreekumar	Upper Division Clerk
52	Smt. Remya T. R.	Upper Division Clerk (On deputation)
53	Smt. Saritha L.	Stenographer Grade III
54	Smt. Dhanya M. B.	Stenographer Grade III
55	Smt. Zulekha	Stenographer Grade III
56	Smt. Sreeja N. P.	Lower Division Clerk
57	Smt. Sandhya C. K.	Lower Division Clerk
58	Shri. Rajesh T. K.	Lower Division Clerk
59	Shri. Biju George	Lower Division Clerk

No	Name of Employee	Designation
MADRAS RESEARCH CENTRE		
60	Shri. Ashish Chobey	Assistant Administrative Officer
61	Shri. S. Yuvarajan	Assistant
62	Shri. A. Yesudhas	Upper Division Clerk
63	Smt. S. Anjalidevi	Upper Division Clerk
64	Shri. S. Maharajan	Lower Division Clerk
65	Shri. R. Kumaran	Lower Division Clerk
MANDAPAM REGIONAL CENTRE		
66	Smt. M. Rameswari	Assistant
67	Shri. B. James	Upper Division Clerk
68	Shri. M. Shahul Hameed	Upper Division Clerk
69	Shri. B. Palanivelmurugan	Upper Division Clerk
70	Shri. M. Saravanan	Lower Division Clerk
71	Smt. M. Valarmathi	Lower Division Clerk
72	Shri. R. Saravanan	Lower Division Clerk
MANGALORE RESEARCH CENTRE		
73	Shri. U. Purandhara Shetty	Assistant
74	Shri. Upendar Kumar	Assistant
MUMBAI RESEARCH CENTRE		
75	Shri. Vinod P. Bhagayatkar	Assistant
TUTICORIN RESEARCH CENTRE		
76	Smt. T. Mahalakshmi	Assistant
77	Shri. J. Vinoth Prabhu Vaz	Assistant
78	Shri. K. Jerald Raja	Assistant
79	Shri. W. Sathyavan Neelraj	Assistant
80	Smt. R. Anantharani	Upper Division Clerk
VERAVAL REGIONAL CENTRE		
81	Shri. Chandra Mauli Sharma	Assistant Administrative Officer
82	Shri. Vanvi Mansukhlal Madhavji	Assistant
83	Shri. Rohit A. Chowda	Lower Division Clerk
84	Shri. Pandya Jatinkumar Jethalal	Lower Division Clerk
VISAKHAPATNAM REGIONAL CENTRE		
85	Smt. G. Hemlata	Assistant Finance & Accounts Officer
86	Smt. D. Madhavi Latha	Assistant
87	Shri. L. Pydi Raju	Upper Division Clerk
88	Shri. S. Srinivasulu	Lower Division Clerk
VIZHINJAM RESEARCH CENTRE		
89	Smt. Radhika Krishnan	Assistant
90	Smt. K. Latha	Assistant
91	Smt. M. P. Kaladevi	Upper Division Clerk

Skilled Support

No	Name of Employee	Designation
CALICUT RESEARCH CENTRE		
1	Smt. Nishida P.	Skilled Support Staff
2	Shri. M. K. Chandran	Skilled Support Staff
3	Shri. P. Satheeshkumar	Skilled Support Staff
4	Shri. M. P. Devadasan	Skilled Support Staff
5	Shri. P. V. Gopalan	Skilled Support Staff
6	Shri. P. B. Jeevaraj	Skilled Support Staff
7	Shri. V. Rajendran	Skilled Support Staff
8	Shri. Anirudh K.	Skilled Support Staff
9	Smt. Vijisha M.	Skilled Support Staff
10	Shri. Anoop K. G.	Skilled Support Staff
KARWAR RESEARCH CENTRE		
1	Shri. Subhash K. Naik	Skilled Support Staff
2	Shri. Ramakant Shankar Harikantra	Skilled Support Staff
3	Smt. Nandini Mayekar	Skilled Support Staff
4	Shri. T. P. Renilkumar	Skilled Support Staff
5	Ms. Pooja Mahabaleswar Gajinkar	Skilled Support Staff
6	Shri. Vineeth T.	Skilled Support Staff
7	Ms. Veena Ulhas Kamble	Skilled Support Staff
8	Shri. Ravichandra Angadi	Skilled Support Staff
9	Shri. Manoj Rajendra Hulaswar	Skilled Support Staff
10	Shri. Nagaraj Mohan Durgekar	Skilled Support Staff
11	Shri. Suraj Surendra Kalgutkar	Skilled Support Staff
KOVALAM FIELD LAB		
1	Shri. V. Jayapradeep	Skilled Support Staff
KOCHI		
1	Shri. K. C. Rajappan	Skilled Support Staff
2	Shri. K. G. Jayaprasad	Skilled Support Staff
3	Shri. T. K. Antony	Skilled Support Staff
4	Smt. K. T. Prakasini	Skilled Support Staff
5	Smt. P. K. Usha	Skilled Support Staff
6	Shri. M. D. Suresh	Skilled Support Staff
7	Smt. Usha. S.	Skilled Support Staff
8	Smt. P. K. Sujatha	Skilled Support Staff
9	Shri. M. J. Joseph	Skilled Support Staff
10	Smt. Subaida K. S.	Skilled Support Staff
11	Smt. K. S. Jeeji	Skilled Support Staff
12	Shri. P. M. Gireesh	Skilled Support Staff
13	Smt. T. R. Kumari	Skilled Support Staff
14	Shri. M. K. Anil Kumar	Skilled Support Staff

No	Name of Employee	Designation
15	Shri. Rajesh P. A.	Skilled Support Staff
16	Smt. Unniresmi C. U.	Skilled Support Staff
17	Shri. Akhil Babu V.	Skilled Support Staff
18	Smt. Rinku Joseph	Skilled Support Staff
19	Smt. Deepa R.	Skilled Support Staff
20	Smt. Vijayalakshmi V. V.	Skilled Support Staff
21	Shri. Kaushik T. R.	Skilled Support Staff
22	Shri. Prashanth P. K.	Skilled Support Staff
23	Shri. Sibin P. Babu	Skilled Support Staff
24	Shri. Ratheesh M.	Skilled Support Staff
25	Ms. Sethulakshmi M.	Skilled Support Staff
26	Shri. Joby P. J.	Skilled Support Staff
27	Smt. Anaswara K. B.	Skilled Support Staff
28	Shri. Pakkri Muthu S.	Skilled Support Staff
29	Smt. Sruthy S.	Skilled Support Staff
30	Smt. Jesli Disilva	Skilled Support Staff
31	Shri. Akhildev S.	Skilled Support Staff
32	Smt. Sreelakshmi S.	Skilled Support Staff
33	Smt. Binitha Babu	Skilled Support Staff
34	Smt. Remya E. A.	Skilled Support Staff
35	Shri. Ullas Shankar	Skilled Support Staff
36	Smt. Jinimol K. P.	Skilled Support Staff
37	Smt. Hima P. H.	Skilled Support Staff
38	Smt. Divya K. A.	Skilled Support Staff
39	Smt. Aswathy A. S.	Skilled Support Staff
40	Shri. Eldhose Benny	Skilled Support Staff
41	Shri. Thobias P. Antony	Skilled Support Staff
42	Shri. Vysakhan P.	Skilled Support Staff
43	Shri. Sujith R.	Skilled Support Staff
44	Smt. Marjana P. M.	Skilled Support Staff
45	Smt. Reshma K. S.	Skilled Support Staff
46	Shri. Abilash Velayudhan	Skilled Support Staff
47	Smt. Keerthy Krishna	Skilled Support Staff
48	Ms. Athira T. G.	Skilled Support Staff
49	Smt. Preethy Udayabhanu	Skilled Support Staff
50	Shri. Vipinkumar K. K.	Skilled Support Staff
51	Shri. Jerin V. Jose	Skilled Support Staff
52	Shri. Augustine Sipson N. A.	Skilled Support Staff
53	Shri. Akhil A. R.	Skilled Support Staff
54	Shri. Seban John	Skilled Support Staff
55	Smt. Emy K Baby	Skilled Support Staff

No	Name of Employee	Designation
56	Smt. Nandana P. R.	Skilled Support Staff
57	Shri. Jithesh P. T.	Skilled Support Staff
KVK, Narakkal		
1	Shri. Jimosh Mohan C M	Skilled Support Staff
2	Shri. Midhun Kumar P. H.	Skilled Support Staff
KVK, Lakshadweep		
1	Shri. Abdul Hakeem M. M.	Skilled Support Staff
2	Smt. Shajala Banu P. M.	Skilled Support Staff
MADRAS RESEARCH CENTRE		
1	Smt. R. Kalaiselvi	Skilled Support Staff
2	Smt. R. Sarojini	Skilled Support Staff
3	Smt. R. Eswari	Skilled Support Staff
4	Ms. P. Prasannakumari	Skilled Support Staff
5	Shri. T. Balaraman	Skilled Support Staff
6	Shri. A. Vinoth	Skilled Support Staff
7	Shri. K. Prabhakaran	Skilled Support Staff
8	Shri. Raja Sekar R.	Skilled Support Staff
9	Shri. R. Yuvaraj	Skilled Support Staff
10	Smt. Niranjana A.	Skilled Support Staff
MANDAPAM REGIONAL CENTRE		
1	Shri. K. Thangavelu	Skilled Support Staff
2	Shri. U. Rajendran	Skilled Support Staff
3	Shri. K. Jeevanandam	Skilled Support Staff
4	Shri. N. Nagamuthu	Skilled Support Staff
5	Smt. Subbulakshmi	Skilled Support Staff
6	Shri. K. Ganesan	Skilled Support Staff
7	Shri. N. Ramamoorthy	Skilled Support Staff
8	Smt. M. Saraswathi	Skilled Support Staff
9	Shri. N. Thirupathi	Skilled Support Staff
10	Shri. A. Bose	Skilled Support Staff
11	Shri. K. Narayanan	Skilled Support Staff
12	Smt. M. Muthuvelu	Skilled Support Staff
13	Shri. T. Jothi Manikandan	Skilled Support Staff
14	Smt. S. Sabiya Begum	Skilled Support Staff
15	Shri. Suresh R.	Skilled Support Staff
16	Shri. A. Mohammed Kaleem	Skilled Support Staff
17	Smt. M. Afrin Rani	Skilled Support Staff
18	Shri. J. Ramachandran	Skilled Support Staff
19	Shri. M. Mahalingam	Skilled Support Staff
20	Smt. K. Madhavi	Skilled Support Staff
21	Shri. Ravikumar T. T.	Skilled Support Staff
22	Shri. B. Sravanakumar	Skilled Support Staff

No	Name of Employee	Designation
23	Shri. R. Rajkumar	Skilled Support Staff
24	Shri. Aneesh U.	Skilled Support Staff
25	Shri. S. Joseph Jegan	Skilled Support Staff
26	Ms. Divya Bharathy S.	Skilled Support Staff
27	Shri. Midhun Muthayan	Skilled Support Staff
28	Shri. M. Saravanakumar	Skilled Support Staff
29	Shri. S. Mahalinga Naik	Skilled Support Staff
30	Smt. Thanujakshi	Skilled Support Staff
31	Shri. Shrinath B.	Skilled Support Staff
32	Shri. Nagaraj Somayya Gond	Skilled Support Staff
33	Smt. Sathyavathi	Skilled Support Staff
34	Ms. Pushpa K.	Skilled Support Staff
35	Shri. Dharmaraju L. B.	Skilled Support Staff
36	Shri. Naveen Raju K. G. Naik	Skilled Support Staff
MUMBAI RESEARCH CENTRE		
1	Shri. K. K. Baikar	Skilled Support Staff
2	Shri. D. D. Jangam	Skilled Support Staff
3	Smt. Urmila S. Balmiki	Skilled Support Staff
4	Shri. Ashish C. S. Chaturvedi	Skilled Support Staff
5	Shri. Vicky Kumar Prajapati	Skilled Support Staff
6	Shri. Suresh	Skilled Support Staff
7	Shri. Vaibhav Milan Tawde	Skilled Support Staff
8	Shri. Vaibhav Jayant Gharat	Skilled Support Staff
9	Shri. Asharam Choudhary	Skilled Support Staff
TUTICORIN RESEARCH CENTRE		
1	Shri. Santhakumar A.	Skilled Support Staff
2	Shri. S. Alagesan	Skilled Support Staff
3	Shri. I. Ravindran	Skilled Support Staff
4	Shri. S. Mariappan	Skilled Support Staff
5	Shri. M. Soundrapandian	Skilled Support Staff
6	Shri. M. Kalimuthu	Skilled Support Staff
7	Shri. K. Subramanian	Skilled Support Staff
8	Shri. A. Paul Pondi	Skilled Support Staff
9	Smt. A. Usha Rani	Skilled Support Staff
10	Shri. C. S. Santhanakumar	Skilled Support Staff
11	Shri. K. Chandran	Skilled Support Staff
12	Shri. K. Krishnan	Skilled Support Staff
13	Shri. K. Anandan	Skilled Support Staff
VERAVAL REGIONAL CENTRE		
1	Shri. Haridas Khimdas Makwana	Skilled Support Staff
2	Smt. Santok A. Bharada	Skilled Support Staff
3	Shri. Bhint Mitesh Hiralal	Skilled Support Staff

No	Name of Employee	Designation
4	Shri. Chorvadi Kamlesh Kalidas	Skilled Support Staff
5	Shri. Thakar Milan Rajnikant	Skilled Support Staff
6	Shri. Mushagra Rajit Hasam	Skilled Support Staff
7	Shri. Gadhiya Noormamad Alibhai	Skilled Support Staff
VISAKHAPATNAM REGIONAL CENTRE		
1	Shri. D. Lingaraju	Skilled Support Staff
2	Shri. Oggu China Venkateswarlu	Skilled Support Staff
3	Shri. R. Pydi Raju	Skilled Support Staff
4	Shri. P. Venkatesh	Skilled Support Staff
5	Shri. Damodara Rao Padumu	Skilled Support Staff
6	Shri. Siram Nookaraju	Skilled Support Staff
7	Shri. Seera Harish	Skilled Support Staff
8	Shri. Potala Bhaskara Rao	Skilled Support Staff
9	Shri. Venkateswarulu Vuyyala	Skilled Support Staff
10	Shri. Yenni Prasad Babu	Skilled Support Staff
11	Shri. P. Shanmukh Deekshit Kumar	Skilled Support Staff
12	Shri. Palli Kalidasu	Skilled Support Staff

No	Name of Employee	Designation
VIZHINJAM RESEARCH CENTRE		
1	Smt. T. Jayakumari	Skilled Support Staff
2	Shri. S. Satheesh Kumar	Skilled Support Staff
3	Ms. Sharanya M. P.	Skilled Support Staff
4	Ms. Krishna Priya P. M.	Skilled Support Staff
5	Smt. Shalini O.	Skilled Support Staff
6	Smt. Nisha S.	Skilled Support Staff
7	Shri. Greever Yoyak V.	Skilled Support Staff
8	Smt. Arathy R Pillai	Skilled Support Staff
9	Shri. V. Anand	Skilled Support Staff

Research Projects

In-house

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
1	FRA/GIS/01	Geo-referenced online information system for marine fisheries on GIS platform to formulate management strategies for sustainable harvest of resources	Dr. T. V. Sathianandan FRAD	Dr. J. Jayasankar Dr. Somy Kuriakose Dr. Mini K. G. Dr. Grinson George Shri. Vinaykumar Vase Shri. Vivekanad Bharti Dr. Eldho Varghese Shri. Wilson T. Mathew	2017-2024
2	FRA/CHL/02	Chlorophyll based Remote sensing assisted Indian Marine Fisheries Forecasting System (ChloRIFFS)	Dr. J. Jayasankar FRAD	Dr. T. V. Sathianandan Dr. Prathibha Rohit Dr. Somy Kuriakose Dr. K. G. Mini Dr. R. Jeyabaskaran Dr. Grinson George Dr. Eldho Varghese Shri. Vinaykumar Vase Shri. Vivekanad Bharti	2017-2020
3	PEL/RMS/03	Resource assessment and management framework for sustaining marine fisheries of Karnataka and Goa	Dr. Prathibha Rohit PFD	Dr. A. P. Dineshbabu Dr. Sujitha Thomas Dr. Geetha Sasikumar Dr. K. M. Rajesh Dr. Bindu Sulochanan Dr. G. B. Purushottama Dr. Divya Viswambharan Dr. K. G. Mini Dr. P. S. Swathilekshmi Dr. P. Shinoj	2017-2024
4	PEL/LPR/04	National fishery management framework for large pelagic resources	Dr. E. M. Abdussamad PFD	Shri. K. P. Said Koya Dr. Prathibha Rohit Dr. M. Sivadas Dr. A. Margaret Muthu Rathinam Dr. U. Ganga Dr. Shubhadeep Ghosh Dr. K. M. Rajesh Shri. K. Mohammed Koya Dr. Anulekshmi Chellappan Smt. S. Surya Shri. Nakhawa Ajay Dayaram Dr. Subal Kumar Roul Shri. P. Abdul Azeez Shri. R. Vinoth Kumar Smt. Shikha Rahangdale Shri. K. M. Manas Dr. K. G. Mini	2017-2020

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
5	PEL/NEC/05	Resource assessment and management framework for sustaining marine fisheries of the West Bengal and Odisha	Dr. Gyanaranjan Dash CFD	Dr. Subal Kumar Roul Dr. Swatipriyanka Sen Dash Shri. Rajesh Kumar Pradhan Shri. Vivekanand Bharti Dr. Shyam S. Salim	2017-2022
6	PEL/LAK/06	Resource assessment and management framework for sustaining marine fisheries of the fishery of Lakshadweep	Shri K. Mohammed Koya PFD	Dr. K. M. Rajesh Shri. P. G. Ambarish Shri. K. P. Said Koya Dr. Subal Kumar Roul Shri. P. Abdul Azeez Smt. S. Surya Dr. Prathibha Rohit Dr. E. M. Abdussamad Dr. M. Sivadas Dr. P. Shinoj Shri. Vivekanad Bharti Dr. P. S. Swathilekshmi Dr. K. R. Sreenath Dr. U. Ganga Smt. Remya Raj	2017-2020
7	DEM/RMS/07	Resource assessment and management framework for sustaining marine fisheries of Kerala	Dr. T. M. Najmudeen DFD	Dr. P. U. Zacharia Dr. Rekha J. Nair Dr. Livi Wilson Shri. P. G. Ambarish Dr. V. Mahesh Dr. E. M. Abdussamad Dr. U. Ganga Dr. Subal Kumar Roul Shri. K. P. Said Koya Smt. S. Surya Dr. Josileen Jose Dr. S. Lakshmi Pillai Dr. Rekha Devi Chakraborty Dr. K. N. Saleela Dr. V. Venkatesan Dr. R. Vidya Dr. P. K. Asokan Dr. P. Gomathi Dr. V. Kripa Dr. D. Prema Dr. Shelton Padua Dr. Somy Kuriakose Dr. N. Aswathy Dr. M. K. Anil Shri. K. Mohammed Koya	2017-2024
7	DEM/RMS/SUB/07	Monitoring and assessment of juvenile fishery along the coast of Kerala	Dr. T. M. Najmudeen DFD	Dr. P. U. Zacharia Dr. T. V. Sathianandan Dr. S. Lakshmi Pillai Smt. Livi Wilson Dr. V. Venkatesan Dr. V. Mahesh Shri. P. G. Ambarish Dr. K. N. Saleela Dr. Subal Kumar Roul Dr. Shyam S. Salim	2017-2020

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
8	PEL/RMS/08	Resource assessment and management framework for sustaining marine fisheries of Tamil Nadu and Puducherry	Dr. M. Sivadas PFD	Dr. Shoba Joe Kizhakudan Dr. A. Margaret Muthu Rathinam Dr. P. T. Sarada Dr. E. M. Chhandaprajnadarsini Dr. P. P. Manoj Kumar Dr. I. Jagadis Ms. M. Kavitha Smt. Shikha Rahangdale Shri. Rajan Kumar Shri. R. Vinoth Kumar Smt. L. Remya Shri. M. Rajkumar Dr. K. N. Saleela Dr. R. Narayanakumar Dr. Grinson George	2017-2024
9	DEM/RMS/09	Resource Assessment and Management framework for sustaining Marine Fisheries of Gujarat	Dr. Vinaykumar Vase FRAD	Smt. Shikha Rahangdale Shri. P. Abdul Azeez Shri. Rajan Kumar Dr. Kapil S. Sukhdhane Shri. Tarachand Kumawat	2017-2022
10	DEM/RMS/10	Resource Assessment and Management framework for sustaining Marine Fisheries of Andhra Pradesh	Dr. M. Muktha DFD	Dr. Shubhadeep Ghosh Dr. Indira Divipala Dr. F. Jasmin Dr. L. Loveson Edward Dr. S. S. Raju Dr. H. M. Manas Dr. Eldho Varghese	2017-2024
11	DEM/ELS/11	Developing management plans for sustainable exploitation and conservation of elasmobranchs in India	Dr. Shoba Joe Kizhakudan DFD	Dr. Sujitha Thomas Dr. P. U. Zacharia Dr. P. P. Manoj Kumar Dr. Rekha J. Nair Dr. T. M. Najmudeen Dr. Muktha Menon Dr. G. B. Purushottama Dr. Swatipriyanka Sen Dash Dr. K. V. Akhilesh Smt. Remya L. Dr. Livi Wilson Shri. P. G. Ambarish Dr. V. Mahesh Dr. Shikha Rahangdale Dr. Subal Kumar Roul Dr. Shyam S. Salim Shri. Rajesh Kumar Pradhan	2017-2020

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
11	DEM/ELS/SUB/11	Assessing the status of elasmobranchs protected under the Indian Wildlife (Protection) Act 1972	Dr. K. V. Akhilesh DFD	Dr. Shoba Joe Kizhakudan Dr. Sujitha Thomas Dr. P. U. Zacharia Dr. P. P. Manoj Kumar Dr. Rekha J. Nair Dr. T. M. Najmudeen Dr. Muktha Menon Dr. G. B. Purushottama Dr. Swatipriyanka Sen Dash Smt. L. Remya Dr. Livi Wilson Shri. P. G. Ambarish Dr. V. Mahesh Dr. Shyam S. Salim Shri. Rajesh Kumar Pradhan	2017-2020
12	CFD/BPT/12	Development of guidelines for “Best practices” for trawl fishery in India	Dr. A. P. Dineshbabu CFD	Dr. Sujitha Thomas Dr. Anulekshmi Chellappan Dr. Indira Divipala Dr. Shubhadeep Ghosh Dr. Gyanranjan Dash Dr. Swatipriyanka Sen Dash Shri. Rajesh Kumar Pradhan Dr. K. V. Akhilesh Dr. R. Ratheeshkumar Shri. Nakhava Ajay D. Dr. K. M. Rajesh Dr. Purushottama G. B. Dr. Mahesh V. Dr. G. Maheswarudu Dr. Josileen Jose Dr. S. Lakshmi Pillai Dr. Rekha Devi Chakraborty Dr. T. M. Najmudeen Shri. M. Rajkumar Shri. Rajan Kumar Dr. P. T. Sarada Dr. M. Sivadas Dr. Shoba Joe Kizhakudan Smt. Shikha Rahangdale Dr. R. Narayanakumar Dr. P. S. Swathilekshmi	2017-2020
13	CFD/RMS/13	Resource Assessment and Management framework for sustaining marine fisheries of Maharashtra	Dr. Anulekshmi Chellappan PFD	Dr. S. Ramkumar Dr K. V. Akhilesh Dr. R. Ratheesh Kumar Shri. Ajay D. Nakhawa Shri. Santhosh N. Bhendekar Dr. Somy Kuriakose Dr. Shyam S. Salim	2017-2024

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
14	CFD/REC/14	Implications of recruitment dynamics and spatio-temporal stock assessment of marine prawns of India for fisheries management	Dr. P. T. Sarada CFD	Dr. S. Lakshmi Pillai Dr. Rekha Devi Chakraborty Dr. K. N. Saleela Dr. A. P. Dineshbabu Dr. R. Ratheesh Kumar Dr. Gyanranjan Dash Dr. Indira Divipala Shri. M. Rajkumar Shri. Rajan Kumar	2017-2020
	CFD/REC/SUB/14	Investigations on commercial lobster fishing and live lobster trade in India	Dr. K. N. Saleela CFD	Dr. P. T. Sarada Dr. Rekha Devi Chakraborty Dr. Gyanranjan Dash Shri. R. Ratheesh Kumar Shri. M. Rajkumar Shri. Rajan Kumar	2017-2020
15	MFD/BIV/15	Fishery Management Plans (FMPs) and recruitment dynamics of bivalves	Dr. Geetha Sasikumar MFD	Dr. K. S. Mohamed Dr. P. K. Asokan Dr. I. Jagadis Dr. V. Venkatesan Dr. R. Vidya Dr. F. Jasmin Smt. M. Kavitha Smt. E. M. Chhandapranjandarsini Smt. P. Gomathi Shri. Bhandekar Santhosh Nagnath	2017-2024
16	MFD/GTR/16	Assessment of ornamental gastropod fisheries and studies on the shell-craft industry in India	Dr. I. Jagadis MFD	Dr. V. Venkatesan Dr. Shyam S. Salim Smt. M. Kavitha Dr. F. Jasmin Dr. E. M. Chhandaprajnadarsini Shri. Rajesh Kumar Pradhan	2017-2020
17	MFD/MOL/17	Popularizing eco-friendly molluscan farming strategies	Dr. P. K. Asokan MFD	Dr. K. S. Mohamed Dr. I. Jagadis Dr. M. K. Anil Dr. Geetha Sasikumar Dr. V. Kripa Dr. P. Kaladharan Dr. V. P. Vipinkumar Dr. R. Vidya Dr. N. S. Jeena Shri. Santosh Nagnath Bhendekar Dr. E. M. Chhandaprajnadarsini Smt. M. Kavitha Shri. Rajesh Kumar Pradhan	2017-2024

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
18	MDN/HCY/18	Development of hatchery technologies for commercially important species in mariculture	Dr. R. Jayakumar MCD	Dr. Imelda Joseph Dr. K. Madhu Dr. Rema Madhu Dr. Gulshad Mohammed Dr. Boby Ignatius Dr. Shoji Joseph Dr. Joe K. Kizhakudan Dr. B. Santhosh Dr. A. K. Abdul Nazar Dr. Jayasree Loka Dr. T. Senthil Murugan Dr. G. Tamilmani Dr. P. P. Sureshbabu Dr. M. Sakthivel Dr. Ritesh Ranjan Shri. C. Kalidas Dr. P. Rameshkumar Dr. Biji Xavier Shri. N. Rajesh Dr. D. Divu Dr. Sekar Megarajan Dr. K. K. Anikuttan Dr. M. T. Shilta Shri. M. Sankar Shri. S. Chandrasekhar Dr. Sanal Ebeneezar	2017-2024
19	MDN/CGE/19	Innovations in Sea cage farming & coastal mariculture	Dr. Imelda Joseph MCD	Dr. Jayasree Loka Dr. T. Senthil Murugan Smt. Saloni Shivam Shri. K. Reghu Ramudu Dr. A. K. Abdul Nazar Dr. R. Jayakumar Dr. G. Tamilmani Dr. P. Rameshkumar Dr. M. Shaktivel Dr. B. Johnson Dr. K. K. Anikuttan Shri. M. Sankar Dr. Ritesh Ranjan Dr. Biji Xavier Dr. Sekar Megarajan Shri. D. Linga Prabu Dr. K. Madhu Dr. Rema Madhu Dr. Boby Ignatius Dr. Shoji Joseph Shri. N. Rajesh Dr. N. Aswathy Dr. A. Anuraj Dr. A. P. Dinesh Babu Dr. Sujitha Thomas	2017-2020

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
				Dr. Joe K. Kizhakudan Dr. D. Divu Shri. V. Vinaykumar Dr. Gulshad Mohammed Dr. P. P. Sureshbabu Dr. M. T. Shilta Dr. P. P. Manoj Kumar Dr. C. Kalidas Dr. B. Santhosh Dr. M. K. Anil	
20	MDN/REP/20	Analysis of reproductive characteristics of selected potential species for mariculture	Dr. Shoji Joseph MCD	Dr. Imelda Joseph Dr. Boby Ignatius Dr. B. Santhosh Dr. P. P. Suresh Babu Dr. Jayasree Loka Dr. A. K. Abdul Nazar Dr. K. K. Anikuttan Dr. M. Sakthivel Dr. G. Tamilmani Dr. Muktha Menon Shri. N. Rajesh Dr. M. T. Shilta	2017-2020
21	MDN/FAD/21	Assessing the performance of artificial reefs deployed along north Tamil Nadu coast	Dr. Joe K. Kizhakudan MCD	Dr. P. Laxmilatha Dr. R. Narayanakumar Dr. Shoba Joe Kizhakudan	2017-2020
22	MDN/GRO/22	Delineating the compensatory growth pattern in stunted fingerlings of marine finfishes for production enhancement	Dr. Suresh Babu P. P. MCD	Dr. Imelda Joseph Dr. Boby Ignatius Dr. R. Jayakumar Dr. M. T. Shilta Dr. P. Shinoj Dr. A. K. Abdul Nazar Dr. K. K. Anikuttan Shri. M. Shankar Dr. A. Anuraj	2017-2020
23	MBT/HLT/23	Health management in selected finfish and shellfish & bio-prospecting from marine resources	Dr. N. K. Sanil MBTD	Dr. Sandhya Sukumaran Dr. M. A. Pradeep Dr. P. K. Asokan Dr. S. R. Krupesha Sharma Dr. M. K. Anil Dr. Joe K. Kizhakudan Dr. Ritesh Ranjan Dr. P. Rameshkumar Smt. K. J. Reshma Dr. T. G. Sumithra Ms. S. Saloni Shivam Smt. Saima Rehman Shri. Raghu Ramudu Dr. Jayasree Loka	2017-2020
	MBT/HLT/SUB 23	Development of bioactive pharmacophores from marine organisms	Dr. Kajal Chakraborty MBTD		2017-2020

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
24	MBT/NTM/24	Marine food fish, ornamental fish and lobster nutrition research for mariculture	Dr. P. Vijayagopal MBTD	Dr. Boby Ignatius Dr. Joe K. Kizhakudan Dr. C. P. Suja Dr. Vidya Jayasankar Dr. Kajal Chakraborty Shri. C. Kalidas Shri. D. Linga Prabu Shri. S. Chandrasekar Dr. Sanal Ebeneezar Shri. Adnan Hussain Gora Smt. K. J. Reshma Dr. T. G. Sumithra	2017-2020
25	MBT/GEN/25	Genetic and Genomic approaches for fishery resource management, conservation and sustainable mariculture	Dr. Sandhya Sukumaran MBTD	Dr. A. Gopalakrishnan Shri. V. Srinivasa Raghavan Dr. N. S. Jeena Dr. Sekar Megarajan	2017-2020
26	MBT/TSU/26	Biomineralization of mantle tissue from pearl producing molluscs	Dr. C. P. Suja MBTD	Dr. Vidya Jayasankar Shri. V. Srinivasa Raghavan	2017-2019
27	FEM/HBT/27	Micro-level environmental management plans for selected critical habitats for ecosystem health and sustainable production	Dr. D. Prema FEMD	Dr. V. Kripa Dr. Shelton Padua Dr. R. Jeyabaskaran Dr. Reeta Jayasankar Dr. P. S. Asha Dr. Bindu Sulochanan Dr. Loveson Edward L. Shri. Kapil S. Sukhdhane Shri. S. Thirumalaiselvan Smt. Ramya Abhijith Dr. R. Narayanakumar Dr. K. Sunil Kumar Mohamed Dr. P. Kaladharan	2017-2020
	FEM/HBT/SUB/27	Impact of climate extremes and disasters on ecosystem functioning with special emphasis on fisheries and mariculture	Dr. V. Kripa FEMD	Dr. K. Sunil Kumar Mohamed Dr. D. Prema Dr. R. Jayabaskaran Dr. Shelton Padua	2017-2020
28	FEM/PLN/28	Abatement of coastal pollution through bioremediation	Dr. Reeta Jayasankar FEMD	Dr. D. Prema Dr. P. Kaladharan Dr. K. Vijayakumaran Dr. P. S. Asha Dr. Bindu Sulochanan Dr. Loveson Edward Shri. Kapil S. Sukhdhane Shri. S. Thirumalaiselvan	2017-2020
	FEM/PLN/SUB/28	Assessment of coastal and marine pollution in selected maritime states of India	Dr. P. S. Asha FEMD	Dr. D. Prema Dr. R. Jeyabaskaran Dr. Bindu Sulochanan Dr. Loveson Edward L. Shri. K. S. Sukhdhane Dr. Shelton Padua Shri. S. Thirumalaiselvan Smt. Ramya Abhijith	2017-2020

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
29	FEM/MPH/29	Marine macrophytes in India-Resources dynamics and ecosystem services	Dr. P. Kaladharan FEMD	Dr. R. Narayanakumar Dr. R. Jeyabaskaran Dr. K. Vijayakumaran Dr. B. Johnson Shri. Thirumalaiselvan S. Shri. Kapil S. Sukhdhane Smt. Remya Abhijith Dr. Reeta Jayasankar Dr. Loveson Edward L.	2017-2020
30	MBD/CNS/30	Developing conservation plan for biologically sensitive areas along the Indian coast	Dr. K. Vinod MBD	Dr. K. K. Joshi Dr. R. Narayanakumar Dr. Molly Varghese Dr. S. Jasmine Dr. K. S. Sobhana Dr. Miriam Paul Sreeram Dr. K. R. Sreenath Shri. Saravanan R. Shri. L. Renjith Shri. S. Ramkumar Dr. Pralaya Renjan Behera Dr. Divya Viswambharan Shri. Tarachand Kumawat	2017-2020
31	MBD/CRL/31	Assessment of resilience potential of coral reefs	Dr. K. R. Sreenath MBD	Dr. K. K. Joshi Dr. S. Jasmine Dr. P. Laxmilatha Dr. K. S. Sobhana Dr. Molly Varghese Dr. K. Vinod Dr. Miriam Paul Sreeram Dr. Saravanan R. Shri. L. Renjith Shri. S. Ramkumar Dr. Pralaya Renjan Behera Dr. Divya Viswambharan Shri. Tarachand Kumawat Dr. K. Mohammed Koya	2017-2024
32	MBD/JLY/32	Investigations on the scyphozoan and cubozoan jellyfishes diversity and distribution along the Indian coast	Dr. R. Saravanan MBD	Dr. S. Jasmine Dr. P. Laxmilatha Dr. K. Vinod Dr. K. S. Sobhana Dr. Miriam Paul Sreeram Dr. K. R. Sreenath Shri. Tarachand Kumawat Dr. L. Ranjith Dr. Divya Viswambharan Dr. Pralaya Renjan Behera Dr. S. Ramkumar	2017-2020

Sl. No.	Project Code	Title of the Project	PI of the Project & Division	Co-PIs	Duration
33	SEE/SOC/33	Socio-economic assessment of marine fisheries resource use and management in India	Dr. R. Narayanakumar SEETTD	Dr. S. S. Raju Dr. C. Ramachandran Dr. Shyam S. Salim Dr. P. S. Swathilekshmi Dr. N. Aswathy Dr. B. Johnson Dr. P. Shinoj	2017-2024
34	SEE/GOV/34	Responsible Marine Fisheries Governance: Compliance analysis and peripatetic capacity development	Dr. C. Ramachandran SEETTD	Dr. P. Shinoj Dr. S. S. Raju Dr. V. P. Vipinkumar Dr. B. Johnson Shri. Tarachand Kumawat	2017-2020
	SEE/GOV/SUB/34	A study on compliance to fishery regulations along the Indian coastline	Dr. P. Shinoj SEETTD	Dr. C. Ramachandran Dr. S. S. Raju Dr. V. P. Vipinkumar Dr. B. Johnson Shri. Tarachand Kumawat	2017-2020
35	SEE/DCD/35	Marine Fish distribution and consumption demand in India : A policy outlook	Dr. Shyam S. Salim SEETTD	Dr. R. Narayanakumar Dr. V. P. Vipinkumar Dr. S. S. Raju Dr. P. S. Swathilekshmi Dr. Swatipriyanka Sen Dash Dr. T. V. Sathianandan	2017-2024
36	SEE/GEN/36	Alternate livelihood options and gender mainstreaming for entrepreneurship development in marine fisheries sector of India	Dr. P. S. Swathilekshmi SEETTD	Dr. R. Narayanakumar Dr. V. P. Vipinkumar Dr. Shyam S. Salim Dr. Reeta Jayasankar Dr. B. Johnson Dr. Nikita Gopal (CIFT)	2017-2020
	SEE/GEN/SUB/36	Mainstreaming the gender perspective of SHGs in Indian fisheries sector	Dr. V. P. Vipinkumar SEETTD	Dr. R. Narayanakumar Dr. P. S. Swathilekshmi Dr. Shyam S. Salim Dr. Reeta Jayasankar Dr. C. Ramachandran Dr. N. Aswathy	2017-2020
37	MBT/DNA/37	Environmental DNA (eDNA) metabarcoding – based estimation of marine stocks	Dr. P. Jayasankar MBTD	Dr. K. G. Mini Dr. M. A. Pradeep	2017-2019

Research Projects

Externally Funded

Sl. No.	Title of the Project	Principal Investigator	Funding Agency	Duration	Total cost (₹ lakhs)
1	National Surveillance project on aquatic animal diseases	Dr. N. K. Sanil	NFDB	2015-2020	122.01
2	Development of small molecular weight angiotensin II converting enzyme inhibitors from marine organisms	Dr. Kajal Chakraborty	DBT	2017-2020	54.00
3	AINP on fish health	Dr. N. K. Sanil	ICAR	2017-2020	51.00
4	National Initiative on Climate Resilient Agriculture (NICRA)	Dr. P. U. Zacharia	ICAR	2012-2021	249.00
5	Consortium research project on diagnostics and vaccines	Dr. N. K. Sanil	ICAR	2015-2020	363.16
6	Network programme on Assessment of Antimicrobial Resistance (AMR) in microorganisms associated with fisheries and aquaculture in India	Dr. K. R. Krupesha Sharma	Network Project - AMR	2018 - 2020	--
7	A model for the primary production in Indian coastal waters	Dr. T. V. Sathianandan	DST	2017-2020	48.26
8	CO_2 assimilation off Cochin and Mandapam coast	Dr. T. V. Sathianandan	NRSC	2017-2020	48.00
9	Pathways of Dispersal for Cholera and Solution Tools (PODCAST)	Dr. Mini K. G.	DBT	2019-2021	35.53
10	Rehabilitation of *Vibrio* infested water of Vembanad Lake: pollution and solution (REVIVAL)	Dr. Somy Kuriakose	DST	2018-2021	99.34
11	Response surface and mixture experiment methodologies for process/product optimization	Dr. Eldho Varghese	LBS – YS Award 2017 ICAR	2019-2022	30.00
12	Molecular taxonomy and phylogeny of cones (cone snails) and strombs (Mollusca, Gastropoda) of the Indian coast	Dr. P. Laxmilatha	DBT	2016-2020	58.53
13	Valuation of marine and coastal ecosystem in Kadalundi community reserve of Kerala	Dr. K. Vinod	KSBB	2017-2020	9.00
14	Taxonomical Investigation of lesser known marine animals of India - Phylum: Cnidaria (Class: Anthozoa) and Phylum: Porifere (Marine)	Dr. K. K. Joshi	AICOPTAX-MoEF&CC	2018-2021	20.38
15	Our common future ocean in the earth system – quantifying coupled cycles of carbon, oxygen, and nutrients for determining and achieving safe operating spaces with respect to tipping points (COMFORT)	Dr. K. R. Sreenath	MoES - NERCI	2019-2023	121.00
16	Policy Imperatives for Promoting Value Chains of Agricultural Commodities in India	Dr. Shinoj and Dr. C. Ramachandran	Network project with National Institute of Agricultural Economics and Policy Research (NIAP)	2018-2020	34.00

Sl. No.	Title of the Project	Principal Investigator	Funding Agency	Duration	Total cost (₹ lakhs)
17	Assessing the financial viability/ sustainability of *Theeramythri* enterprises	Dr. Shyam S. Salim	SAF, Dept. of Fisheries, Govt. of Kerala	2018-2020	5.00
18	Fish Market and Price Information System (FMPIS)	Dr. Shyam S. Salim	NFDB-E-market	2019-2020	189.00
19	Fisher welfare impact assessment on the satellite based ocean information services: an appraisal	Dr. Shyam S. Salim	INCOIS	2018-2020	20.22
20	Empowerment of scheduled caste fisher folk through entrepreneurial capacity building of self-help groups in marine sector	Dr. Vipinkumar V. P.	DST-SEED	2019-2022	26.49
21	Pedagogic and pragmatic dimensions of vocational education system: A diagnostic study on employability of fisheries students	Dr. Reshma Gills	ICAR – Extramural	2019-2022	13.51
22	Knowledge value chains for sustainable marine fisheries management: A diagnostic assay in an eco-polity spiral system of governance	Dr. Reshma Gills	IMPRESS – ICSSR	2019-2021	15.69
23	Benchmarks for Ecosystem Assessment : Indicators and guidelines for practical Ecosystem Based Fishery Management (EBFM)	Dr. Sunilkumar Mohamed	CSIRO	2018-2021	44.00
24	Sustainable alternative livelihood for coastal fishing communities along Palghar district of Maharashtra : Molluscan mariculture approach	Shri. Bhendekar Santosh Nagnath	Mangrove Cell, Govt of Mahareshtra	2019-2022	26.62
25	Piloting and upscaling of PAN India Fisher Friend Mobile Application in Karnataka	Dr. Prathbha Rohit	MSSRF	2017-2020	6.00
26	Impact, vulnerability and adaptation strategies for marine fisheries of India	Dr. A. Gopalakrishnan	NATCOM	2016-2020	25.30
27	Identification, forecasting and monitoring of potential fishing zone for Tamil Nadu coastal and offshore waters (SAMUDRA TDP R&D)	Dr. Shoba Joe Kizhakudan	SAC-ISRO	2017-2020	33.70
28	Study on shark and non-fin commodities	Dr. Shoba Joe Kizhakudan	FAO	2019-2020	56.30
29	AINP on mariculture	Dr. Boby Ignatius	ICAR	2017-2020	1025.00
30	Enhancing production of farmed Cobia (*Rachycentron canadum*) through the establishment of broodbank and supply of larvae to States for seed production	Dr. A. K. Abdul Nazar	NFDB	2016-2020	813.80
31	Enhancing production of farmed Silver Pompano through the establishment of broodbank, supply of larvae to States for seed production	Dr. M. K. Anil	NFDB	2016-2020	843.00
32	Open water cage culture in selected District in Kerala and Karnataka	Dr. Imelda Joseph	NFDB	2017-2020	1328.70
33	Cage culture demonstration of orange spotted grouper (*Epinephelus coioides*) in Andhra Pradesh using CMFRI technology	Dr. Shubhadeep Ghosh	NFDB	2017-2020	370.80
34	Demonstration of pond culture technology for two high value marine fin fishes in salt affected areas of Andhra Pradesh by ICAR-CMFRI	Dr. Sekar Megarajan	NFDB	2018-2020	65.02
35	Network project on Ornamental Fish Breeding and Culture	Dr. K. Madhu	Network Project	2018-2023	--
36	Brackishwater cage culture in Sindhudurg district in Maharashtra	Dr. Shoji Joseph	NFDB	2019-2020	1483.20
37	Extensive demonstration of technology of open sea cage farming of marine finfishes all along the territorial waters of coastal States/UTs	Dr. R. Jayakumar	NFDB	2019-2021	515.00
38	Documentation, assessment and taxonomic studies on cynoglossids and soles of India	Dr. Rekha J. Nair	AICOPTAX-MoEF&CC	2019-2022	31.96
39	Mapping of wetlands in Andaman and Nicobar Island	Dr. A. P. Dineshbabu	ISRO-SAC	2019-2021	13.80

Research Projects

Consultancy

Sl. No.	Project	Client	Principal Investigator	Period	Amount (Lakh)
1	Installation of artificial reefs in the inshore waters of seventeen villages along Tamil Nadu coast	Director of Fisheries, Dept. of Fisheries, Tamil Nadu	SIC, Madras RC of CMFRI	2012-2019	260.8
2	Consultancy on livelihood enhancement of fishermen through deployment of AR in inshore waters along the six districts of Tamil Nadu (TN)	The Project Director IFAD assisted PTSLP TN Corporation for development of women 100 Anna Salai, Guindy, Chennai	Dr. Joe K. Kizhakudan	2015-19	92.98
3	Artificial fish habitat based marine ecosystem restoration in the inshore areas off Bhadreshswar, Kutch District, Gujarat.	Commissioner of Fisheries (Fy.) Commissionerate of Fy. Third Floor, Block No.10, Jivraj Mehta Bhavan, Gandhi Nagar, Gujarat	Dr. Sreenath K. R.	2016-Continuing	359.37
4	Setting up of Modern Aquarium at Dept. of Fisheries, UT of Lakshadweep, Kavaratti.	Chief Executive Officer, Dept. of Fisheries, UT of Lakshadweep, Kavaratti- 682 555	Dr. M. K. Anil	2016-2019	54.7
5	Impact study of proposed Vadhavan Port on coastal fisheries	Jawaharlal Nehru Port Trust, Mumbai	Dr. Anulekshmi C.	2016- Continuing	94.08
6	Marine water quality monitoring at SPM area of M/s MRPL-3	MRPL Mangalore	Dr. Prathibha Rohit	2018-2019	5.01
7	Sea water and treated effluent monitoring of M/s MRPL	MRPL Mangalore	Dr. Prathibha Rohit	2018-2019	13.57
8	Site selection and deployment of artificial reefs in inshore waters along the coast of Six districts in Tamil Nadu	Project Director, IFAD assisted PTSLP, Guindy, Chennai.	Dr. Laxmilatha	2019- Continuing	39.79
9	Baseline study on impact of coastal road on fisheries and fisher livelihood, Maharashtra	Municipal Corporation of Greater Mumbai	Dr. Anulekshmi C.	2019- Continuing	41.42
10	Performance assessment of fishing fleet in India	BoBP, No. 91 St. Mary's Road, Abhiramapuram, Chennai-18	Dr R. Narayanakumar	2019	2.83
11	Site selection for deployment of AR in inshore waters of three districts of north TN	Dept of Fisheries, Tamil Nadu	Dr Joe K. Kizhakudan	2019-Continuing	49.56
12	Sea water and treated effluent monitoring of M/s MRPL-4	MRPL Mangalore	Dr. Prathibha Rohit	2019-Continuing	13.57
13	Assessment of impact of seismic surveys on fisheries off Palghar, Maharashtra	Oil and Natural Gas Corporation Ltd. (ONGC) Mumbai	Dr. K. V. Akhilesh	2019-Continuing	45.43
TOTAL					1073.11

Research Management and Staff Welfare

26th IRC meeting of CMFRI Headquarters

Recommendations of the 23rd RAC

- CMFRI may complete preparation of marine fisheries management guideline documents for all the coastal states.
- U.T's and two Island ecosystems and evaluate adoption of the guidelines by the user agencies.
- Local issues in capture fisheries, biodiversity and mariculture may be identified and addressed by each regional and research center through short-term technical programmes in the existing research projects to find focused solutions.
- CMFRI may provide scientific inputs to international and regional initiatives/ agreements on addressing Illegal, Unreported and Unregulated fishing; implementing on a pilot scale, Ecosystem Approach to Fisheries Management and Ecosystem Approach to Aquaculture Management; and developing framework for meeting the targets of SDG 14.
- To estimate the potential yield of mesopelagic resources in the Indian EEZ.


1.

- Identification of bottlenecks for chosen species for which breeding success is yet to be achieved.
- Developing mass hatchery production in collaboration with relevant organizations.
- Evaluation of cage culture prospects in terms of seed and feed availability, economic feasibility in the background of proposed expansion by the governments.
- Strengthening research on seaweed farming including agarophytes and alginophytes; extend IMTA activity to states other than Tamil Nadu with an emphasis on marketing the products
- Performance assessment of nutraceuticals developed by CMFRI.
- Additional AINPs on ornamental fishes, marine microbial diversity including in deep sea regions may be planned.
- Inter-institutional research programmes may be taken up.
- Analyse the fishery regulatory formalities in India to assess the existing mechanisms to ensure responsible fisheries governance and to map the level compliance by the fishing community.
- Discuss/take up activities on biodiversity beyond national jurisdiction.
- Take up awareness programmes on by catch reduction devices and develop programmes for sustainable harvest.
- Bring out policy briefs for focusing the fishery related issues of the coastal states
- Popularise coastal cage culture activities and other programmes focusing on doubling the fisher's income.

The 24th Research Advisory Committee (RAC) reconstituted for the succeeding three years is tabled below.

Name and address of RAC Members	
Dr. Ms. B. Meenakumari, Former DDG (Fisheries Science), ICAR	Chairperson
Dr. E. Vivekanandan, Former Head, Demersal Fisheries Division, ICAR-CMFRI	Member
Dr. Niranjan Sarangi, Former Director, ICAR-CIFA	Member
Prof. K. S. Uduppa, Former Professor, College of Fisheries, Mangalore	Member
Dr. Pravin Puthra, Assistant Director General (Marine Fishereis) ICAR	Member
Dr. M. Chandrasekharan, Adjunct Professor, Department of Biotechnology, CUSAT	Member
Shri P. Hariharan, Kurukkamparya House, Chilanka Beach, Vadanapally	Member
Shri K. Muralidharan, 1/28, Siddivinayakar Koil Street, Mandapam	Member
Dr. A. Gopalakrishnan, Director, ICAR-CMFRI	Member
Dr. K. K. Joshi, Principal Scientist & Head in charge, MBD. ICAR-CMFRI	Member Secretary

Institute Research Council (IRC)

Mid-Term IRC, 4-5 December 2019

The mid-term Institute Research Council meeting was held at ICAR-CMFRI, Kochi during 4-5 December, 2019. Dr. Prathibha Rohit, Secretary IRC welcomed everyone to the midterm IRC and informed all that this midterm IRC was being held as an action point of the main IRC held during June 2019. Only Heads of Divisions and PI of new in-house projects proposed to be taken

1. Dr. A. Gopalakrishnan, Director, ICAR-CMFRI chairing the 86th IMC meeting at Mandapam RC

2. 14th IJSC Meeting in progress at Headquarters

2.

up in 2020 attended the meeting. Further, only the in-house projects which will be completed with highlights of the work completed and closed in March 2020 and those that requires extension beyond March 2020 with justification were presented. The Director once again welcomed everyone to the meeting and informed that two major committees 1. Quinquennial Review Team (QRT and 2. Research Advisory Committee (RAC) effective from January 2020 the have been constituted by ICAR. The pre-QRT Meeting with DDG was held on 25th November 2019 and this is being followed by the first meeting of the QRT members on 20th December, 2019. Director further presented the highlights of activities and informed that the institute is most likely to get the DBT Dr. E. G. Silas Centre of Excellence and it would immensely benefit the Biotechnology and Mariculture Divisions. The DBT has also sanctioned a project worth Rs. 83 lakhs on the biology and seed production of *Lutjanus johni* submitted by Dr. Ritesh Ranjan, Scientist, Visakhapatnam Regional Centre. Other major achievements include submission of the Mariculture Policy draft to the Ministry, publication of the first International book by the on Lobsters by Springer Publication, Publications of Marine fisheries Policy for Tamil Nadu and management plans for Live bait for Lakshadweep and paper on Silver Pompano by Dr. Divu and team in PLOS and great success of the first *Kisan Mela*. Dr. Kajal Chakraborty informed that CMFRI had the maximum number of (eight) patents in fisheries and six more are in the pipeline, Director urged all Scientists to apply for more external funded projects. Director concluded his remarks and conveyed that DDG had urged all scientists to increase the quality as well as number of publications. The Chair informed that twenty-five main projects and six subprojects that were to be completed during March 2020 were presented. Of these, eleven main projects and six sub-projects were closed. Fourteen main projects and one subproject were extended. Twelve new projects were proposed in place of closed projects/ subprojects. All Principal Investigators of all the new project proposals were requested to submit detailed project proposal in RPPI to PME Cell, Principal Investigators of all projects that will be completed by March 2020 and the new proposers have to update details in HYPM and if any changes are there in the names of scientists in existing projects have to intimated to the PME Cell and make the necessary changes to be made in HYPM.

26th Institute Research Council

The 26th Institute Research Council meeting was held at ICAR-CMFRI, Kochi during 11-15 June 2019. The major outcome, contributions and achievements of the Institute was presented. The Chairman also pointed out the need to initiate preparation of the next EFC document with the involvement of all Scientists in the Divisions and Centres. Dr. Reshma Gills, Scientist transferred from IASRI and attending the IRC for the first time was welcomed to the meeting. The retirement of two of the senior-most colleagues of the Institute Dr. Maheswarudu, Principal Scientist and Head I/c, Crustacean Fisheries Division and Dr. Sivadas, Principal Scientist, Pelagic Fisheries Division during this financial year and retirement of Dr. Sunil Mohamed, Principal Scientist & Head I/c, Molluscan Fisheries Division before the next IRC was also mentioned. The Director welcomed all members once again in his introductory remarks and mentioned that the establishment of a new Department of Fisheries at the Centre has increased the responsibility of the Institute. Director recalled the salient achievements made by the Institute during 2018-19. Estimation of the marine fishery production trend of the country along with the gross revenue generated, contribution of CMFRI in arriving at the potential yield of the Indian EEZ up to 500 m, publishing marine policy briefs for management of marine fisheries, advisory on turtle nesting grounds, prediction on oil sardine landings, new species records, nursery rearing protocols for green mussels, nutraceuticals, collaborative projects and excellent publications by the scientists were highlighted. The Heads of Division and Principal Investigators made brief presentations of the major activities and progress made by the respective Divisions/ projects. In all the progress made in 37 in-house projects along with sub-projects and 37 externally funded Projects was presented and discussed. Activities and Progress made by the Krishi Vigyan Kendra (KVK) Kochi, Krishi Vigyan Kendra, Kavaratti, Lakshadweep; Human Resource Development Cell, Library and Documentation Section; Estate and Maintenance Cell; the Priority setting and Monitoring Cell (PME), and the Vessel Management Cell (VMC) were presented by the respective Scientists-in-Charge.

During the IRC presentations, two special sessions, the first was on Day three when the Chairman announced that a paper entitled 'Formal versus informal: Insights into the credit transactions of small-scale fishers along the south west coast of India' authored by Dr. Shinoj P. and team and published in International Journal, Marine Policy had been discussed in the Kerala Assembly and the recommendations made in the paper were accepted and would be implemented.

Institute Management Committee

The 86th meeting of the Institute Management Committee of CMFRI was held on 07.12.2019 at Mandapam Regional Centre of CMFRI, Mandapam Camp. The Director and Chairman, IMC presented a brief about the research achievements made by the Institute. Action taken on the previous meeting held on 22.12.2018 was reviewed. IMC recommended the proposal for procurement of Molecular modelling software/database and high speed computer and digital interface for molecular modelling under Sub head– Information Technology (IT) for the year 2019-20. The IMC recommended the proposal for procurement of Gas Chromatograph Mass Spectrometer and Twin Screw Extruder. The IMC recommended the proposal for Providing Solar Power Energy through RESCO/PPA Mode at Mandapam Regional Centre of CMFRI and for Providing Cauvery Water at Mandapam Regional Centre of CMFRI, Mandapam Camp. The Institute Management Committee also recommended to the proposal for Shifting of Marine Fish Museum and Aquarium near to Madurai-Rameswaram Highway Within the Centre's campus. The members of IMC expressed satisfaction on the research achievements of the Institute.

IJSC meeting

The 2nd meeting of the 14th IJSC of CMFRI was held on 23.10.2019. Status and solutions to several staff welfare issues were discussed and decided.

Training and Capacity Building

Field visit by African-Asian Rural Development Organization training participants

The HRD Cell at CMFRI coordinates the training and capacity building activities, besides facilitating doctoral and internships programmes for research scholars


1.

Training programs conducted

Several short-term training programs as well as winter/summer schools in specialized areas for the scientists were organized at the Institute. Apart from this, a number of special training programs were also conducted for the benefit of fishermen, aquaculture farmers, entrepreneurs, professionals, and other stakeholders. The main areas of skill development include 'Mariculture technologies', 'Application of statistical tools and data analysis', 'Aquarium setting and feed production', and so on.

Capacity Building programmes for employees

During 2019, 16 scientists, 12 technical, 52 administrative and finance as well as 5 skilled supporting staff attended various trainings programmes at CMFRI and other institutes.

Winter school/Short term training

Two training programs including a winter school and an international training for trainees from foreign

Training programmes organized by CMFRI during 2019-20

Sl. No.	Subject of Training	Place
1	Application of statistical tools for data analysis and interpretation in prawn recruitment dynamics	CMFRI, Kochi
2	Aquarium Setting and fish feed production	CMFRI, Kochi
3	On the Job training programme in fisheries and aquaculture	CMFRI, Kochi
4	Procedures and practices for maintenance and up keeping of Marine Taxonomy Lab/Museum	CMFRI, Kochi
5	Sea cage farming	CMFRI, Kochi
6	Recent Technological Advances in Mariculture technologies	CMFRI, Kochi
7	Orientation for Fishery Department staff	CMFRI, Kochi
8	Hands-on training on fish ageing using hard parts	CMFRI, Kochi
9	Cage aquaculture for finfishes	Karwar RC of CMFRI
10	Production of value added products from seaweed to enhance the income of the fishers	Tuticorin RC of CMFRI
11	Live feed culture, larviculture and nursery rearing of Marine finfishes	Mandapam RC of CMFRI
12	Mariculture hatchery operations	Mandapam RC of CMFRI
13	Feed preparation for cage culture of marine fin fishes and shellfishes"	Tuticorin RC of CMFRI
14	Biology work of pelagic resources	Mangalore RC of CMFRI
15	Cage construction and installation for TSP beneficiaries	Calicut RC of CMFRI

1. Workshop cum Training Programme on 'Fisheries and Aquaculture' for trainees from AARDO countries
2. Training programme for fish farmers on 'Cage Farming'
3. Administration training

countries were organized during 2019 and are listed below.

Winter School

"Mariculture Technologies: Principles and practices to augment the seafood production in India", during 6-27 November 2019. (Course Director: Dr. Sakthivel, Scientist, Mandapam RC).

International Training Programme

International Training on 'Fisheries and Aquaculture' for participants from 10 member countries of African-Asian Rural Development Organization (AARDO) held at CMFRI Headquarters, Kochi during 15-29 October, 2019 sponsored by AARDO New Delhi, India. (Course Director: Dr. Imelda Joseph)

Ph.D. Programmes

Presently, 86 scholars are pursuing their doctoral degree programmes at CMFRI, Kochi and its centres under various universities. Five scholars were awarded their degrees during 2019-20.

Major Events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1. Honourable Director Genral ICAR and Secretary DARE, Govt. of India at CMFRI on 25 May 2019
2. Global Expert Meeting on collection and reporting on use of Shark and Ray Commodities 24-27 July 2019
3. First National Symposium on the Enigmatic Indian Oil Sardine on 6 August 2019
4. Citizen Science network inauguration and project partners donation for house construction of flood-affected to Dr. M. S. Sunil
5. Transfer and demonstration of National wetland mobile application and website 30 September 2019
6. Swachh Bharath Pledge on 2 October 2019
7. International Workshop-cum-training programme of Fishereis and Aquaculture sponsored by AARDO from 15-29 October 2019
8. CMFRI retains overall title in ICAR South Zone Sports Meet (4th time)
9. Inauguration of Buyer Seller meet at CMFRI on 14 November 2019
10. Stake Holders Workshop on marine fishery resources on 7 June 2019

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Marine Biodiversity Museum

Visitors to the Museum on the CMFRI foundation day

Museum depositions during 2019

A total of 86 specimens were deposited in the museum during the year. This includes 28 species of fishes, 14 species of crustaceans, 11 species of molluscs, 16 species of cnidarians, 4 species of seaweeds and 1 species under miscellaneous, 8 mangroves and 1 acanthocephalan out of which 5 specimens were holotypes. Accession numbers were allotted to all the depositions. The holotypes were *Scomberoides pelagicus* n. sp, GB.31.24.21.5 *Sphyraena* n. sp, GB.31.143.1.6 *Macrobrachium irrawaddiense* n. sp. ED.2.2.1.4, *Myxobolus chanosi* n. sp. CD.1.1.1.1, *Neoechinorhynchus cephali* n. sp HA 2.2.2.5

New specimens added to museum collection

Sl. No.	FISHES	Acc. No.
1	*Chelonodontops bengalensis* Habib, 2018	GB.43.6.7.1
2	*Pomadasys guoraca*	GB31.68.11.22
3	*Xyrias sp.*	GB. 4.13.27.1
4	*Scomberoides pelagicus* n. sp	GB.31.24.21.5
5	*Sphyraena* n. sp.	GB.31.143.1.6
6	*Cephalopholis polleni* (Bleeker, 1868)	GB.31.139.14.5
7	*Nettastoma parviceps* Gunther, 1877	GB.4.12.6.1
8	*Ariosoma anago* (Temminck & Schlegel, 1846)	GB.4.4.5.2
9	*Poecilopsetta colorata* Gunther, 1880	GB.33.7.9.1
10	*Strophidon sathete* (Hamilton, 1822)	GB.49.14.1.1
11	*Bathyclupea hoskynii* (Alcock, 1891)	GB.31.76.1.1
12	*Acanthurus lineatus* (Linnaeus, 1758)	GB.31.1.1.20
13	*Acanthurus mata* (Cuvier, 1829)	GB.31.1.1.22
14	*Acanthurus triostegus* (Linnaeus, 1758)	GB.31.1.1.23
15	*Abudefduf vaigiensis* (Quoy & Gaimard, 1825)	GB.31.122.1.20
16	*Caranx hippos* (Linnaeus, 1766)	GB.31.24.7.8
17	*Chaetodon auriga* Forsskål, 1775	GB.31.33.2.7
18	*Cheilinus chlorourus* (Bloch, 1791)	GB.31.78.9.1
19	*Chlorurus sordidus* (Forsskål, 1775)	GB.31.131.4.16
20	*Halichoeres hortulanus* (Lacepède, 1801)	GB.31.78.26.26
21	*Parupeneus barberinus* (Lacepède, 1801)	GB.31.95.3.3
22	*Parupeneus trifasciatus* (Lacepède, 1801)	GB.31.95.3.26
23	*Scarus scaber* Valenciennes, 1840	GB.31.131.9.42
24	*Thalassoma hardwicke* (Bennett, 1830)	GB.31.78.67.11
25	*Lutjanus argentimaculatus* (Forsskål, 1775)	GB.31.88.7.8
26	*Lutjanus gibbus* (Forsskål, 1775)	GB.31.88.7.31
27	*Aprion virescens* Valenciennes, 1830	GB.31.88.2.2
28	*Caranx ignobilis* (Forsskål, 1775)	GB.31.24.7.9

Sl. No.	CRUSTACEANS	Acc. No.
1	*Lysirude channeri* (Wood-Mason, 1885)	ED.8.1.1.1
2	*Porcellana persica* Haig, 1966	ED.7.1.1.1
3	*Macrobrachium irrawaddiense* sp. Nov	ED.2.2.1.4
4	*Macrobrachium univmandalay*	ED.2.2.1.5
5	*Macrobrachium miyanmarum*	ED.2.2.1.6
6	*Macrobrachium lamarroides*	ED.2.2.1.7

7	*Munida mesembria* Macpherson, Rodriguez-Flores & Machordom, 2017	ED.4.4.2.2
8	*Sicyonia parajaponica* Crosnier, 2003	ED.1.4.1.2.1
9	*Trachysalambria aspera* (Alcock, 1905)	ED.1.3.10.2
10	*Merhippolyte calmani* Kemp & Sewell, 1912	ED. 2.3.2.2
11	*Heterocarpus sibogae* de Man, 1917	ED.2.4.1.3
12	*Eriphia sebana* (Shaw & Nodder, 1803)	ED.5.1.1.1
13	*Dardanus guttatus* (Olivier, 1812)	ED.11.1.1
14	*Actaeodes* sp.	ED.5.8.1.3

Sl. No.	MOLLUSCANS	Acc. No.
1	*Tremoctopus gracilis*	DE.2.1.1.1
2	*Cistopus platinoidus*	DE.3.1.2.9
3	*Harpago* sp.	DB.12.1.1
4	*Cypraea tigris* Linnaeus, 1758	DB.15.1.16
5	*Lyncina vitellus orcina (var)* (Linnaeus, 1758)	DB.15.2.9
6	*Monetaria caputserpentis* (Linnaeus, 1758)	DB.15.2.1
7	*Mauritia histrio* (Gmelin, 1791)	DB.15.2.5
8	*Monetaria moneta* (Linnaeus, 1758)	DB.15.2.6
9	*Naria erosa erosa* (Linnaeus, 1758)	DB.15.2.7
10	*Lyncina propinqua* (Garrett, 1879)	DB. 15.2.8.1
11	*Conus (Virroconus) ebraeus* Linnaeus, 1758	DB.35.1.6.1

Sl. No.	CNIDARIANS	Acc. No.
1	*Catostylus perezi* Ranson, 1945	CB.3.1.1.2
2	*Myxobolus chanosi* n. sp.	CD.1.1.1.1
3	*Rhopilema hispidum* (Vanhöffen, 1888)	CB.3.1.1.3
4	*Cassiopea andromeda* (Forsskål, 1775)	CB.3.1.1.4
5	*Cyanea nozakii Kishinouye, 1891*	CB.3.1.1.5
6	*Chrysaora chinensis Vanhöffen, 1888*	CB.3.1.1.6
7	*Chrysaora hysoscella* (Linnaeus, 1767)	CB.3.1.1.7
8	*Chiropsoides buitendijki* (van der Horst, 1907)	CB.3.1.1.8
9	*Pocillopora damicornis* (Linnaeus, 1758)	CF.1.2.11.1.1
10	*Crambionella annandalei, Rao, 1931*	CB.3.1.1.1
11	*Psammocora* sp.	CF.1.14.1.1
12	*Acropora tenuis* (Dana, 1846)	CF.1.1.1.33
13	*Tubastrea micranthus* (Ehrenberg, 1834)	CF.1.13.3.2
14	*Lobophyllia corymbosa* (Forskål, 1775)	CF.1.9.2.1.1
15	*Lobactis scutaria* (Lamarck, 1801)	CF.1.5.3.2.1
16	*Fungia fungites* (Linnaeus, 1758)	CF.1.5.3.3.1

Sl. No.	SEAWEEDS	Acc. No.
1	*Halophila stipulacea* (Forsskal) Ascherson, 1867	A1A.1.2.1.3
2	*Halodule pinifolia* (Miki) den Hartog, 1964	A1A.1.1.2.2
3	*Halophila beccarii* Ascherson, 1871	
4	*Gracilaria tenuistipitata C. F.Chang & B.-M.Xia*	AC.3.1.1.7

Sl. No.	NEMATODA	Acc. No.
1	*Philometra philippinensis*	CE 1.1.1.1

Sl. No.	MISCELLANEOUS	Acc. No.
1	*Acroteriobatus variegatus*	Misc. 39

Sl. No.	MANGROVES	Acc. No.
1	*Rhizophora mucronata* var. selala Salvoza	AE.1.9.1.1
2	*Excoecaria agallocha* L.	AE.1.9.1.2
3	*Bruguiera cylindrica* (Linnaeus) Blume	AE.1.9.1.3
4	*Aegiceras corniculatum* (L.) Blanco	AE.1.9.1.4
5	*Avicennia alba* Blume	AE.1.9.1.5
6	*Clerodendrum* inerme (L.) Gaertn.	AE.1.9.1.6
7	*Avicennia officinalis*	AE.1.9.1.7
8	*Morinda citrifolia* Linn.	AE.1.9.1.8

Sl. No.	ACANTHOCEPHALA	Acc. No.
1	*Neoechinorhynchus cephali* n. sp	HA 2.2.2.5

Visitors to the Museum

Month	No. of schools	No. of students	No. of colleges	No. of students	Public	Total
April	1	75	4	104	190	369
May	2	53	4	125	463	641
June	0	0	2	74	81	155
July	3	181	13	503	142	826
August	3	283	7	284	99	666
September	5	289	10	497	111	897
October	5	289	9	485	111	885
November	18	1364	9	261	165	1790
December	6	427	19	764	215	1406
Total	43	2961	77	3097	1577	7635

VIP Visitors to the Museum

Sl. No.	Name
1	Mr. Ahammed Flayyih Hussan, Ministry of agriculture Bagdad Iraq
2	Mr. Bashir Ahmad Bdawie Alrahleh, Researcher Amman-Jordan
3	Mr. Hussein Shmoury, Ministry of Agriculture, Lebanon
4	Mr. William Chirwa, Karonga Northern. Region, Malawi
5	Mr. Luther Bin Moguup, Selangor, Malaysia
6	Mr. Ravin Hassea, Aibion, Mauritius
7	Mr. Abounahel Najem, Rabat, Morocco
8	Mr. Mohammad Khalfan Nasser Al Alawi, Sultanate Oman
9	Mr. Samindalakmal Jayawickrama Arachchige, Sri Lanka
10	Mr. Zyangani Chirambo, Zambia

Krishi Vigyan Kendra

Michigan State University students on farmer field visit

Under graduate students in social sciences and their faculty from Michigan State University, USA visited KVK's partner farmer fields located at Neericode, Manjummel and Thammanam in Ernakulam District of Kerala

Ernakulam

KVK sets up homestead poultry units

KVK has set up poultry units in selected homesteads of Narakkal Grama Panchayath to create a model that produce quality eggs at villages and supply to city consumers in branded packets. The poultry units consisting of cages, birds and feed were distributed by Dr. A. Gopalakrishnan, Director, CMFRI, Kochi on 29th May 2019. The funding was provided by ICAR-Central Plantation Crops Research Institute, Kasaragod under its Scheduled Caste Sub Plan. The 45 number of units distributed are expected to produce one lakh eggs per year. Though many housewives in the city are interested to rear poultry and produce safe and quality eggs, lack of enough space is the preventing factor. On the other hand, house wives in the villages like Narakkal are looking for income by not compromising their regular works at home. It is in this context that the KVK chalked out the said programme.

KVK launches Farm Service Centre (FSC) to support farmers

In an effort to combat shortage of skilled labour for farming activities in the district, the KVK has launched a farm service centre equipped with a wide range of farm machineries, equipments and trained technicians to offer paid services in all kinds of farm activities. Dr. A Gopalakrishnan, Director, CMFRI inaugurated the FSC on 3rd June, 2019. The centre is equipped with machineries such as tractors, power tiller, power weeder, different types of ploughs, rotavators, earth augers, motorized and hand operated sprayers, paddy transplanter, agro waste shredder, slurry pump, water pump *etc*. In addition, scientific advisories are also provided through FSC. This new initiative would be beneficial to hundreds of farmers in the district who are struggling due to the shortage of technically trained manpower.

Students from Michigan State University visited KVK's partner farmer fields

The under-graduate Social sciences students and faculty from Michigan State University, USA visited KVK's partner farmer fields located at Neericode, Manjummel and Thammanam in Ernakulam District of Kerala on 11thJune 2019. The visits were as part of the Student Exposure Training Programme (SETP) at ICAR-CMFRI, Kochi. Banana farming, vegetable farming, integrated farming system, medicinal plant cultivation and homestead farming models were demonstrated followed by a lecture on *Agro ecological paradigms of Kerala* by Dr. P. Muralidharan, Principal Scientist and Head, ICAR- KVK Alappuzha of ICAR-Central Plantation Crops Research Institute.

1. Dr. A. Gopalakrishnan, Director, CMFRI distributing poultry units
2. Dr. A. Gopalakrishnan, Director, CMFRI inaugurating Farm Service Centre
3. Pearlspot seed production technology training batch

Pearlspot seed production technology trainings conducted

KVK conducted two training programmes on Pearl spot seed production technology during 2-3rd July 2019 and 29-30th August 2019. Objective of these training programmes is to develop pearlspotseed entrepreneurs. KVK extends marketing support to such entrepreneurs through a buy back arrangement. KVK is currently marketing Pearlspot seeds produced by such trained farmers.

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KVK conducted Sales melas to supply quality Agro-inputs to farmers

KVK organizes regular sales melas to supply various agro-inputs to farmers. On 10th June2019, KVK organized one day vegetable seedling sales mela at Palluruthy. Shri. C. K. Peethambaran, President, Palluruthy Block Panchayat inaugurated the mela. Total 12600 numbers of high yielding varieties of tomato, brinjal, chilly, cowpea, Okra and curry leaf saplings were supplied to farmers.

KVK also conducted three sales melas to distribute poultry chicks on 3rdApril 2019, 19th June 2019 and 27thJune 2019at CMFRI, Kochi. More than 2500 numbers of chicks of Kadaknath, Thalasseri, Australorp and RIR breeds worth 5.65 lakhs were distributed.

KVK conducted a Pearlspot seed sales mela at CMFRI, Kochi on 28th June 2019 where in 8000 seeds could be supplied.

On 12th July 2019, KVK conducted fruit sapling sales mela at CMFRI, Kochi.

Total of 4521 saplings of mango, jackfruit, guava, papaya, rose apple, Indian gooseberry, egg fruit, curry lemon, small lemon, garcinia, west indian cherry, passion fruit, star apple, tissue culture banana along with seed propagated curry leaf and bush pepper were made available for sale.

KVK live web casted Hon'ble Prime Minister's speech

KVK web casted the speech of Honb'le Prime Minister Shri. Narendra Modi during inauguration of National Animal Disease Control Programme (NADCP) for foot and mouth disease and brucellosis and nationwide artificial insemination programme held on 11th September 2019. The webcasting was done at CMFRI, Kochi. Dr. Sheeba Issac, Chief Veterinary Officer and Dr. Baby Joseph, Deputy Director, Animal Husbandry Department participated.

1. Palluruthy Block Panchayath President, Shri. C. K. Peethambaran inaugurating KVK's vegetable seedling sales mela
2. Poultry chicks sales mela at CMFRI
3. Inauguration of tree planting campaign at KVK
4. International yoga day at KVK

Tree planting Campaign conducted

As part of the tree plantation campaign held Nationwide on the occasion of the birth day of Hon'ble Prime minister Shri. NarendraModi, the KVK planted 3200 saplings of casuarina and 600 mangroves at its campus on 17th September 2019. The programme was conducted in association with Department of Forest& Wildlife, Kerala. Smt. Mini Dileep, Member of Narakkal Grama Panchayat inaugurated the programme. Mr. A. Manikandan, State Marketing Manager, Indian Farmers Fertiliser Cooperative Limited (IFFCO) participated.

International yoga day celebrated

KVK celebrated the fifth international yoga day on 21st June 2019. Volunteers from Isha Foundation, Coimbatore Dr. Radhika Jayakumar and Dr. Bindu Regha taught upa yoga to the staff. Eco-friendly yoga mats produced by *Khadi Grama Soubhagya* were only used for the programme.

Lakshadweep

ICAR- KVK-Lakshadweep observed Jalshakti Abhiyan, 2019

As part of the national drive for water conservation by the Govt of India, the KVK-Lakshadweep observed the *Jalshakthi abhiyan* on awareness of conservative use of water for agriculture and allied activities with a wide participation of school children, farmers, public and official of the administration at Kavaratti Island, Lakshadweep. The week long programme comprised of awareness programmes and competitions for the school children on the theme "Agriculture and water conservation in Lakshadweep", training programmes for the farmers and women self-help groups, awareness class to the public etc. held during the last week of September, 2019. The programme focussed on optimum use of water in farming with focus on increasing the water use efficiency, adopting different methods like drip irrigation for more crop per drop; conservation and harvesting of rainwater, smart irrigation scheduling *etc.*

The programme culminated with the *Kisan Mela* (*Jal Shakti Abhiyan Mela*) held on 2nd October, 2019. The Mela was inaugurated by Shri Mohammed Faizal, Honourble Member of Parliament, Lakshadweep in the august presence of Sri Om Prakash Mishra, Secretary (Agriculture and Fisheries), U.T. of Lakshadweep and Mr. B Hassan, President and Chief Councillor, District Panchayath, Lakshadweep amidst participation of a plethora of audience. Day long Mela comprised of exhibition by ICAR–Krishi Vigyan Kendra Lakshadweep, development departments of U.T. of Lakshadweep, women SHG's etc. depicting their technologies, products and services for the farmers and the public. The Mela attracted wider attention of the public and large number of people visited the mela and availed the services. Winners of various competitions for the school children were facilitated with trophies and certificate by the dignitaries during the inaugural function of the *Jalshakti Abhiyan Mela*, 2019.

ICAR-KVK-Lakshadweep issues soil health card to the farmers of Lakshadweep

The ICAR-KVK-Lakshadweep together with the Kerala Agricultural University (KAU) Rice Research Station (RRS), Vyttila issued Soil Health Cards (SHC) to the farmers at Kavaratti as a pilot programme of the KVK. Soil from the selected farmers' sites was collected as per the protocol for analysis and issue of SHC by the KAU, Thrissur. In the initial programme 15 famers, who are participating with the KVK's technical programmes were benefitted. Thus, the first ever Soil Health Card issued in Lakshadweep was given away by Shri O. P. Mishra, Secretary (Agriculture), U.T. of Lakshadweep along with other dignitaries during the inaugural programme of the Jalshakti Abhiyan, 2019 on 2nd October, 2019. The Secretary (Agriculture) desired that the ICAR-KVK-Lakshadweep take up this programme at U.T. level with the funding support of the U.T. Administration early so that farming can be done more precisely in the islands.

Pashu Arogya Mela and live telecast of Prime Minister's Speech to farmers

The ICAR-KVK-Lakshadweep carried out *Pashu Arogya Mela* on 11th September, 2019 as per the instruction of the Govt. of India on the occasion of launching of National Animal Disease Control Programme for FMD and Brucellosis and National Artificial Insemination Programme by the Hon'ble Prime Minister

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of India. The inaugural programme and the speech of Honourable Prime Minister were live streamed at KVK-Lakshadweep. The programme followed vaccination drive at Kavaratti in participation with the Department of Animal Husbandry, Lakshadweep. Nearly 40 farmers participated and 16 dairy cows were artificially inseminated or vaccinated.

Important Training Programmes

Two days training programme on "Importance Soil types and homestead farming practices" was conducted at KVK, Kavaratti on 2-3 October, 2019 with the collaboration of the Rice Research Station, Vyttila of Kerala Agricultural University (KAU), Thrissur. The training sessions were handled mainly by Dr. Sreelatha, A. K., Head, RRS, Vyttila and the subject matter specialists of the KVK. 50 farmers comprising of individual farmers and members of the SHG's attended the training. The training programme was inaugurated by Mr B Hassan, President, District Panchayath, Lakshadweep.

The KVK-Lakshadweep partners with the Lakshadweep Administration in the Commercial Scale Aquaponics unit under the Kavaratti Smart City Project

The ICAR-KVK-Lakshadweep joined the Lakshadweep administration, Department of Agriculture in the commercial scale aquaponics programme under the Kavaratti Smart City project. The KVK was involved in the fish husbandry of the aquaponics. Three 10-ton capacity fish tanks in the aquaponic unit were stocked with 2500 numbers of GIFT sourced from the commercial hatcheries in the mainland. The fishes exhibited an excellent growth rate and 0.5 tons of tilapia was harvested as per the demand.

Preliminary results indicate success of the KVK mediated Biological control of rodent using Barn Owl

Coconut is the only commercial crop in the islands and is one of the mainstays of the economy of Lakshadweep islands. However, rodent is an alarming problem in coconut farming in Lakshadweep causing an estimated nut damage of nearly 560 tons worth Rs 6 crores per year (@44%

1. View of poster making competition for high school students in connection with Jal Shakti Abhiyan Mela 2019
2. Shri P. P. Mohammed Faizal, Honourable Member of Parliament making presidential remarks during the Inaugural Function of Jal Shakti Abhiyan Mela 2019 at ICAR
3. KVK Lakshadweep Shri O. P. Mishra, Secretary (Agriculture) giving away the soil health card to the farmers of Kavaratti at ICAR – KVK Lakshadweep
4. Dr A. K. Sreelatha, Asst. Professor and Head, RRS, Vyttila handling training session

of 10 Wmillion annual harvested nuts in the island) in Kavaratti island alone. Dense plantation and closely connected canopy provide the rats an aerial life, wanting an avian predator for biological control of the menace.

KVK Lakshadweep partnered with the Department of Agriculture, UT of Lakshadweep in successful re-introduction and scientific management of barn owls at Kavaratti as a pilot programme. The KVK's role was to locate the birds in consultation with the Kerala Forest Department and transport them in specially designed cages, quarantine them at Kavaratti in the aviary designed, release to wild and

1. Aquaponics unit

post release monitoring. Thus, 3 pairs of birds were reintroduced at Kavaratti on 5th April, 2019 after quarantine of 82 days. Only one bird died during quarantine, evidently due to physical damage caused by infighting. The birds were released to the wild on 25th June, 2019. Post release, the birds were noticed to be homing to the aviary and were also found nesting in the aviary as well as other areas at Kavaratti. The birds were evident to be hunting as beheaded rats, owl pellets with rat parts etc. were noticed in many locations. The birds laid eggs in the aviary during November, 2019 and all the five eggs hatched out during December thus adding to the stock. Considering the success of the programme, the Lakshadweep Administration proposes to expand programme by covering more islands in a phased manner. A long-term strategy for barn owl-based control of rodents in Lakshadweep is being drawn.

Official Language Implementation

Director, CMFRI receiving Rajarshi Tandon Puraskar 2019


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Awards and Recognitions

Rajarshi Tandon Award

CMFRI bagged Rajarshi Tandon Award for the 10th time introduced by the ICAR for the excellent Official Language activities among the Institutes situated in 'C' region for the year 2017-18. The award was distributed during the Foundation Day of ICAR organized in NASC complex, New Delhi on 16.07.2019. Dr. A. Gopalakrishnan, Director, CMFRI and Smt. E. K. Uma, Chief Technical Officer (Hindi) received the Award from Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR

Prizes in National Scientific Seminar

Dr. Shinoj P., Scientist, SETT Division of CMFRI attended the National Scientific Seminar on the subject 'Contribution of Fisheries in Indian Economy' held at CIFT, Cochin on 11.07.2019 and presented paper on 'Contribution on Capture Fisheries and Mariculture in Indian Economy' in Hindi. Dr. Shinoj bagged Ist prize for the Best presentation in the Seminar. Vishakapatnam Regional Centre of CMFRI also bagged prize in Poster presentation during Hindi Seminar conducted by CIFT, Vishakapatnam Centre on 20.07.2019.

Kendriya Sachivalay Hindi Parishad Award

Article on Role of Seaweeds in health, wealth and environmental reconcilement in Hindi by Dr. Reeta Jayasankar, Principal Scientist, FEM Division bagged Special Prize among Non- Hindi speaking Region in for All India Hindi Essay Competition conducted by Kendriya Sachivalay Hindi Parishad, New Delhi during July, 2019.

TOLIC Joint Hindi Celebration 2019

In connection with Joint Hindi Celebration-2019 of Kochi Town Official Language Implementation Committee Hindi song competition was conducted at CMFRI on 25.11.2019. Participants from other Member Organisations under Kochi TOLIC attended the competition CMFRI bagged two prizes– Dr. J. Jayasankar, Principal Scientist and Shri Binoy Bhaskaran, Technical Assistant – Third Prize in Hindi Quiz and Smt. Vandana V., Technical Assistant (Hindi Translator)- First Prize in Hindi Song.

Extension activities

Hindi Fortnight Celebration – 2019

With a view to encourage staff members of the Institute to do their work in Hindi and to promote progressive use of Official Language Hindi in the Institute, Hindi Fortnight was observed from 13th to 28th September, 2019 with various programmes. During the period competitions such as Hindi noting and drafting, Hindi cross word, memory test, Hindi writing, Hindi typing etc. and Hindi Workshop on Official Hindi and Spoken Hindi were conducted. Officers and staff members of the Institute attended the programmes with more enthusiasm. The valedictory function of Hindi Fortnight was presided by Dr. A. Gopalakrishnan, Director, CMFRI. Shri N. Jayasankar, IRS, Commissioner of Income Tax was the Chief Guest of the function. Shri Raghunathan K., Administrative Officer welcomed the gathering. Shri Prasant Kumar, Chief Finance and Accounts Officer read out the Message of Hon'ble Minister of Agriculture and Farmers' Welfare on Hindi Fortnight celebration. Prizes were given to the Winners of Hindi competitions and Hindi Incentive Schemes. Rajbhasha Rolling Trophy for getting more points in competitions was

1. Dr. Shinoj receiving prize
2. Shri N. Jayasankar, IRS, Commissioner of Income Tax address staff during the valedictory function of Hindi fortnight celebrations
3. Establishment Section receives the Rajbhasha rolling trophy
4. A Hindi workshop at Headquarters, April 2019
5. Conversation competition October 2019

awarded to Establishment Section. Hindi Incentive prizes for doing original work in Hindi under Govt. of India Scheme and CMFRI Scheme were presented to 7 Staff members of CMFRI.

Hindi Week / Fortnight was observed in all Regional Research Centres of CMFRI with various programmes.

Hindi Workshops

In order to motivate staff members to do their work in Hindi and to increase the use of Official Language in day today work Hindi workshops were conducted on 11.04.2019, 28.09.2019 and 20.12.2019 at Headquarters, Cochin. Hindi workshops were also organised at different Regional / Research centres of CMFRI.

Monthly Hindi Competitions

Under Monthly Hindi Competition Programme of the Institute, competitions such as Hindi Conversation, Hindi News Reading and Hindi Speech were conducted during the months of October, November and December, 2019 respectively.

Meetings / Trainings

Quarterly meetings of Official Language Implementation Committee

During the period 3 meetings of the Official Language Implementation Committee of the Institute were conducted on 02.04.2019, 11.07.2019 and 23.10.2019 respectively.

Half yearly meeting of Town Official Language Implementation committee

Attended meetings of Town Official Language Implementation Committee at Income Tax Office, Cochin on 13.08.2019 and 29.10.2019.

Participation in Conference / Training

Smt. Priya K. M.,Technical Assistant (Hindi Translator) of Mandapam Regional Centre of CMFRI participated in Induction Translation Training Course (English – Hindi and vice versa) conducted by Central Translation Bureau, Department of Official Language, Ministry of Home Affairs from 1st January to 12th February 2020 at Bengaluru.

Shri Rajesh T. K., LDC, CMFRI Headquarters attended and passed Hindi Typing training conducted by Hindi Teaching Scheme, Department of Official Language during February – July 2019 at Kakkanad.

Official Language inspection

Inspection by ICAR

Dr. P. Pravin, ADG (Marine Fisheries), ICAR, New Delhi inspected the Official Language implementation activities of Karwar Research Centre of CMFRI on 01.05.2019, CMFRI Headquarters, Cochin on 26.04.2019 & 23.10.2019 and Mandapam Regional Centre of CMFRI on 07.12.2019.

Shri M. L. Gupta, Deputy Director (OL) and Shri Manojkumar, ACTO (Hindi) inspected the Official Language implementation activities of Mangalore Research Centre of CMFRI on 17.12.2019.

Inspection by Director, CMFRI

Director, CMFRI inspected the OL implementation activities of Mandapam RC of CMFRI on 07.12.2019.

Review of Official Language Implementation activities of Outstations and guidance

The Official Language Implementation activities of all Regional / Research Centres were reviewed in every quarter and necessary suggestions were given for improvement.

Special focus to complete obligatory Training in Regional / Research Centres in Tamil Nadu

Scientists, Technical and Administrative staff of Mandapam Regional Centre of CMFRI are trained by the Institutional arrangements in Hindi Prabodh, Praveen and Pragya courses.

A Word a Day : Under A word a day programme around 216 Hindi words with english equivalents were displayed on Electronic display board and circulated among staff members of Headquarters and Outstations.

Correspondence in Hindi

During the period all the documents (520) under section 3(3) of Official Language Act 1963 were issued in bilingual. Out of 547 letters received in Hindi 526 were replied to in Hindi. Percentage of Hindi correspondence during the period was 57.6% against the target of 55%.

Name plates rubber stamps, Identity cards of staff members, certificates of Headquarters and KVK training programmes, Banners of various programmes, Project Headings of Outstations were prepared bilingually during the period.

Institute Publications in Hindi

CMFRI Newsletter Cadalmin Hindi – Issue Nos. 158,159,160

Matsyagandha- Hindi In- house magazine – Issue No. 4 and 5.

Swachh Bharat Abhiyan

Cleaning of Ariyaman Kushi Beach near Mandapam RC

Swachh Bharat activities at CMFRI is undertaken in CMFRI HQ and its Centers round the year

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Swachh Bharat Abhiyan is a source of inspiration to all around and is counted be the largest behaviour change programme. The mission has a significant improvement in terms of economic, environmental, health and social enrichment.

ICAR- CMFRI has always been keen in taking initiatives and aiming to prevent environmental degradation and is aiming to sustain the gains made in bio-degradable waste management, plastic waste managementand modalities for convergence with other schemes. One of the major epidemic cause of pollution being the plastic waste which has become a pandemic–on land as well as in the world's oceans. While recycling is a big part of keeping our environment safe and clean, reducing consumption is more impactful. And there is no more important category of waste to reduce than–single-use plastic". Single use plastic does not biodegrade, ever. Instead, it breaks apart into smaller pieces, never truly deteriorating. There is hardly a single place on earth that does not know the touch of single use plastic. CMFRI has always been active in creating awareness in this area and has initiated various awareness programs / activities and still commits to continue to do so in future.

ICAR-Central Marine Fisheries Research Institute, Kochi and all Regional / Research Centre's were involved in regular cleaning and maintenance activities in office premises, hatchery, residential area of staff quarters etc. Maintenance of Biogas and vegetable garden, preparation of vegetable patch, roof garden making were also done during this period at various Centre's. Organic waste generated was used for silage preparation and utilized as manure for office plantation as a part of center waste management and minimization commitments. The Institute initiated the plans for the restricted the use of single-use plastic. The collection of waste of plastic origin and its disposal was given emphasis during regular cleaning activities

ICAR-CMFRI, celebrated "*Swachhatha Pakhwada*" from 16-31 December 2019. Special emphasis was given to conduct programs in schools were children of fishers go.

At Veraval Regional Centre–Essay competition conducted at schools, plastic waste collection by school students, cleanliness drive at school campus and plastic waste collection at Somnath beach was organized.

A bike rally was conducted from main office, Karwar RC to Kali River garden, Kodibag the publicize the message of *Swatchh Bharat Abhiyan* in connection with *Swatchhatha Pakhwada* being carried out at the centre during December 16-31, 2019 . Bike rally was carried out to a distance of 5 kms

A cleanliness drive was conducted at Fishing Harbour area, Visakhapatnam. Polythene, plastic and waste materials were collected and disposed off.

KVK's *Swachhatha Pakhwada* activity

Supply of planting media made using sugar industry waste

As part of its *Swachhatha Pakhwada* activity, the Ernakulam KVK of CMFRI demonstrated soil less planting media made from sugar industry waste and supplied 126 numbers of 10 Kg packets during the Food Agro Expo organized by Kerala State Department of Industries

1. Beach walkathon for creation of awareness on use of plastics and its effect on environment
2. *Swachhatha* campaign was organized at Mananchira square of Kozhikode to create awareness among the public
3. Cleanliness drive at Fishing Harbour, Visakhapatnam
4. Felicitating village leaders promoting Nirmal Dhara – A movement for clean and flowing aquatic habitats

and Commerce at Jawaharlal Nehru International Stadium, Kochi during 20th to 23rd December 2019. Sugar Industry waste called "press mud" is abundantly available from sugar mills. Due to the shortage of soil, urban farmers in Ernakulam are finding it difficult to rear crops. It is in this context, Ernakulam KVK developed a planting media using press mud as one component.

Felicitated Smt. Felsi, Member of Ward 9 and Mr. Ramesh, Member, Ward 8 of Mulavukadu Panchayat in a function arranged at CMFRI on 30.12.2019 for their commendable work to regularly collect plastic waste from each of the 350 households 750 households in their wards and give it for recycling. This was an initiative to prevent dumping of plastic waste in open areas and canals, which would enter the estuaries destroying the aquatic habitats. The work done by them is presented in detail and they were honoured with *Ponnada*.

Swachh Bharath Abhiyan activities of KVK

Swachhta Hi Seva programme was conducted at KVK during 11th September to 2nd October 2019. Cleaning of KVK campus premises, approach road and beach were carried out. The plastic wastes and debris deposited during high tide were removed. An awareness programme on promotion of Single use plastics conducted to staff and farmers.

As part of its *Swachhatha Pakhwada* activity, the KVK demonstrated use of Soil less planting media made from Sugar industry waste and supplied 126 numbers of 10 Kg packets during the Food-Agro expo organized by Kerala State Department of Industries & Commerce at Kochi during 20th to 23rd December 2019.

Mera Gaon Mera Gaurav Programme

In connection with the *Mera Gaon Mera Gaurav* programme of CMFRI, an awareness programme on plastic waste management and implementation of green protocol was organized for the students of Fisheries Vocational Higher Secondary School, Narakkal at Edavanakkad UP School, Ernakulam District. The programme was coordinated by Dr. Krupesha Sharma, Chairman and Dr. N. Aswathy, Member Secretary, *Mera Gaon Mera Gaurav* programme of CMFRI. The session was handled by Shri. C. K. Mohanan, Asst. Co-coordinator, *Suchitwa* Mission, Ernakulam. The students were made aware of the potential environmental threats and health hazards of using single use plastics. Demonstrations were also given on the alternatives to single use plastics which can be easily adopted in everyday life.

Karwar research centre of CMFRI has taken up the *Mera Gaon Mera Gaurav* programme at the Nagnathwada village of Karwar, Uttarakannada District. Around 20 fisher folk who have been trained by ICAR-CMFRI under the scheme provided by National Fisheries Development Board, Hyderabad, have taken up Asian seabass farming in GI cages. Cages were installed in Kali estuary after proper site selection. Scientists of the Centre have extended technical support to the farmers through regular visits. Technical inputs beginning from site selection and seed stocking to harvest has been provided by the scientists of the Centre. A harvest *mela* was conducted at the farming site on 15-07-2019 for the successful harvest and sale of fishes after 6 to 8 months rearing period. The centre has conducted the fish farmer's day celebrations in the village involving all the stake holders on 10-07-2019. Selected farmers from the village have been felicitated by ICAR-CMFRI during this occasion. Dr. Jayasree Loka, Dr. Suresh Babu P. P., Smt. Saloni Shivam,

1. Cleaning of Arattuvazhy beach near KVK
2. Awareness programme for students of Fisheries VHSS, Narakkal, Ernakulam
3. Harvest *mela* at Nagnathwada
4. Felicitation of farmers during National Fish Farmer's day celebrations

Dr. Anuraj A., and Shri K. Raghu Ramudu from Karwar Research Centre of CMFRI were actively involved in implementation of the programme.

Scientists of Tuticorin Research Centre of CMFRI implemented *Mera Gavu Mera Gaurav* programme in 14 coastal villages in Thoothukudi District. The various transfer of technology programmes organised by the centre consisted of interface meetings, awareness cum interactive session on World Jellyfish Day, training programs on seaweeds, marine crab grow-out culture and sea cage farming. Training programs on feed preparation for cage culture of marine shellfishes and finfishes and production of value added products from seaweeds were also undertaken for the benefit of fish farmers. A total of 910 fishers/farmers were benefitted through the awareness programmes, interface meetings, trainings and demonstrations and another 75 farmers were facilitated through supply of seeds of sea weeds, cobia, pompano and lobsters.

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Vijayakumaran, M., Radhakrishnan, E. V., Maheswarudu, G., Srinivasa Gopal, T. K. and Lakshmi Pillai, S. 2019. *Post-harvest processing, value addition and marketing of lobsters*. In: Radhakrishnan, E. V., Phillips, B. F. and Gopalakrishnan, A. (Eds.), *Lobsters: Biology, fisheries and aquaculture,* Springer Nature, Singapore.

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Conference/Workshop Presentations

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Sajna, V. H., Zacharia, P. U., Liya V. Benjamin, Akash Somasekharan, Dhanya Joseph, Rojith, G., Sharon Benny and Roshen G. Ninan 2019. Impact of climate change on the feeding habits of Indian oilsardine (*Sardinella longiceps*) along Kerala coast. In: *Book of Abstracts, International Conference on Aquatic Resources and Blue Economy (AQUABE 2019)* 28-30 November 2019. Kochi, India, p. 59.

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Lakshadweep archipelagos. In: *Abstract Proceedings, International Conference on Benthos (ICB 2019)*, 6-8 March 2019, Kochi, India.

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Shinoj, P. 2019. Demographic changes in fishing communities in India. In: *Regional Consultative Workshop on 'Strengthening governance of aquaculture for sustainable development in Asia and related country : Review Studies'*, 5 -7 November 2019, *Bangkok, Thailand*.

Shyam S. Salim, Monolisha, S., Balakrishnan Nair, T. M. and Smitha Rosey Xavier 2019. Fishers welfare and sustainable living: Assessment on socio-economic benefits of satellite information services to comprehend changing climate and weather events of Indian coast. In: *Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET)*, Abstract ID. 47, Spain.

Sumithra, T. G., Reshma, K. J., Akhitha, M. B., Anusree, V. N. and Sanil, N. K. 2019. Addressing antimicrobial resistance in aquatic environment through haemolymph microbiota: Contextualising non-ribosomal synthetase genes with prospective roles. In: *Book of Abstracts, National Seminar on AMR in Indian Fisheries: Measures for mitigation*, 7-8 November 2019, Kochi, India, p. 107.

Suraj Kumar Pradhan, Sambit Priyadarshi, Rajesh Kumar Pradhan, Abuthagir Ibrahim, S. and Nirmal, T. 2019. Exploring current status and better management options for Inland fisheries with the application of Geographical Information system (GIS) in India. In: *Book of Abstracts, 4th PAF Congress on Increasing aquaculture production in India through synergistic approach between multinational industries, domestic entrepreneurs and aquaculturists*, 15-17 November 2019, Bhubaneswar, India.

Venkatesan, V., Mohamed, K. S., Vidya, R., Jenni, B., Alloycious, P. S., Sajikumar, K. K., Jestin Joy, K. M. and Sheela, P. P. 2019. Assessment of physico-chemical parameters of water and sediments of Ashtamudi Estuary, southeast coast of India. In: *Book of Abstracts, Asian-Pacific Aquaculture 2019*, 18-21 June 2019, Chennai, India.

Vipinkumar, V. P., Ramachandran, C. and Reshma Gills 2019. Women in Fisheries: Perspectives on Sustainable livelihood and conservation. In: *Book of Abstracts, National Seminar on Women in conservation*, Kasargod, India.

Zacharia, P. U., Sajna, V. H., Rojith, G., Roshen G. Ninan, Dhanya Joseph, Somy Kuriakose, Grinson George and Akash Somasekharan 2019. Unraveling the influence of oceanographic drivers on fishery of Indian oilsardine along the southeastern coast of Arabian Sea. In: *Book of Abstracts, Sixth Biennial Conference of Ocean Society of India (OSICON-19)*, 12-14 December 2019, Kochi, India, p. 200.

Pamphlets/Leaflets/Posters / Video

Anil, M. K., Gomathi, P., Ambarish Gop, P., Surya, S., Raju, B., Krishna Priya, P. M. and Mohamed, K. S. 2019. *Micro-nursery for seed production of green mussel*. ICAR-Central Marine Fisheries Research Institute, Kochi.

Anil, M. K., Gomathi, P., Rinju, R., Raju, B., Raheem, P. K., Krishna Priya, P. M and Mohamed, K. S. 2019. *Production of green mussel seed using micron-meshed cages for spat rearing*. ICAR-Central Marine Fisheries Research Institute, Kochi.

Dineshbabu, A. P., Sujitha Thomas, Rajesh, K. M., Prathibha Rohit, and Nataraja, G. D. 2019. Customized indigenous finfish cages developed for fish farmers of coastal Karnataka. ICAR-Central Marine Fisheries Research Institute, Kochi.

Divya Viswambharan, Prathibha Rohit, Raju Saravanan, Joshi, K. K. and Srinath, B. *Jellyfishes of Karnataka ICAR-CMFRI Pamphlet No: 67/2019*. ICAR-Central Marine Fisheries Research Institute, Kochi

Laxmilatha, P., Chhandaprajnadarsini, E. M., Srinivasa Raghavan, V., Narayanakumar, R. and Rudramurthy, N. 2019. *Bivalves as a promising food for a healthy life. CMFRI Pamphlet No. 66/2019*. ICAR-Central Marine Fisheries Research Institute, Kochi.

Nazar, A. K. A., Jayakumar, R., Tamilmani, G., Sakthivel, M., Ramesh Kumar, P., Johnson, B., Anikuttan, K. K. and Sankar, M. 2019. Mariculture Technologies of CMFRI (To augment fish production and provide alternate livelihood support). *CMFRI Video No.31/2019*. ICAR-Central Marine Fisheries Research Institute, Kochi.

Prathibha Rohit, Dineshbabu, A. P., Sujitha Thomas, Geetha Sasikumar, Rajesh, K. M., Bindu Sulochanan, Purushottam, G. B. and Divya Viswambharan 2019. *A Brochure of centre activities*. Mangalore Research Centre of ICAR-Central Marine Fisheries Research Institute, Mangaluru, Karnataka, India.

Ramesh Kumar, P., Nazar, A. K. A., Jayakumar, R., Tamilmani, G., Sakthivel, M., Johnson, B., Anikuttan, K. K., Sankar, M., Hanumanta Rao, G., Priya, K. M. and Uma, E. K. 2019. *Hatchery aur palan pinjrom meim palnevale mchaliyom ke rog* (Diseases of cobia in hatchery and grow-out cages) (in Hind). ICAR-Central Marine Fisheries Research Institute, Kochi.

Ramesh Kumar, P., Nazar, A. K. A., Jayakumar, R., Tamilmani, G., Sakthivel, M., Johnson, B., Anikuttan, K. K., Sankar, M., Hanumanta Rao, G., Priya, K. M. and Uma, E. K. 2019. *Hatchery meim pompano machiloyom ko honevale beemariyam (*Diseases of silver pompano in hatchery) (in Hindi). ICAR-Central Marine Fisheries Research Institute, Kochi.

Saravanan, R., Ranjith, L., Laxmilatha, P., Nazar, A. K. A., Joshi, K. K. and Syed Sadiq, I. 2019. *Mannar khadi aur Palk Khadi ki jellyfish vividhatha aur vitharan.* CMFRI Pamphlet No. 71/2019 (in Tamil). ICAR-Central Marine Fisheries Research Institute, Kochi.

Saravanan, R. 2019. Jelly meenkalai patriya ariya thakavalakal. *CMFRI Pamphlet No. 76/2019* (in Tamil). ICAR-Central Marine Fisheries Research Institute, Kochi.

Saravanan, R. 2019. *Jelly Facts*. CMFRI Pamphlet No. 77/2019. ICAR-Central Marine Fisheries Research Institute, Kochi.

Saravanan, R. 2019. *Jellyfish sambandith mahathvapoorn jaankari* (Jelly Facts). *CMFRI Pamphlet No. 78/2019* (in Hindi). ICAR-Central Marine Fisheries Research Institute, Kochi.

Saravanan, R. 2019. *Save turtle. CMFRI Pamphlet No. 81/2019*. ICAR-Central Marine Fisheries Research Institute, Kochi.

Saravanan, R. 2019. Save sea horse. *CMFRI Pamphlet No. 82/2019*. ICAR-Central Marine Fisheries Research Institute, Kochi.

Subal Kumar Roul, Pralaya Ranjan Behera, Rajesh Kumar Pradhan, Saravanan, R., Shubhadeep Ghosh, Prathibha Rohit and Joshi, K K. 2019. *Diversity and distribution of jellyfish along the Odisha coast–First aid measures of jellyfish stings*. ICAR-Central Marine Fisheries Research Institute, Kochi.

Vipinkumar, V. P, Shinoj Subrammannian, Vikas, P. A., Aswathy, N. and Athira, P. V. 2019. *Cage farming* (Flyer), ICAR-Central Marine Fisheries Research Institute, Kochi.

Zacharia, P. U,, Rojith, G. and Najmudeen, T. M. 2019. *ClimFish-NICRA Newsletter*, 3 (1): 24 pp.

Participations

Conferences/Meetings/Workshops/Symposia/Trainings/Deputations

Dr. A. Gopalakrishnan, Director

Review meeting of National Fisheries Development Board (NFDB) funded Projects, NFDB, Hyderabad, 30 April 2019

National Mariculture Policy meeting, New Delhi, 13 May 2019

Blue Economy WG-III Final Report presentation, NITI Aayog, New Delhi, 16-17 May 2019

Kerala State Fisheries Management Council meeting, Thiruvananthapuram, 27 May 2019

Chaired one Session in 9th Asian-Pacific Aquaculture 2019 18-22 June 2019

Meeting with Fisheries Minister, Govt. of India, New Delhi, 25 June 2019

Discussion on the proposed Marine ornamental fisheries project, Kerala with Fisheries Minister to explore possibility of establishing marine ornamental fish breeding centre at Thirumullavaram, Kollam, 02 July 2019

Meeting at Department of Biotechnology (DBT), New Delhi, 08 July 2019

91st ICAR Foundation Day, ICAR Award Ceremony, Innovative Farmers Conclave and SMD level meeting, New Delhi, 16-17 July 2019

Meeting at ICAR-Central Tuber Crops Research Institute (ICARCTCRI) Thiruvananthapuram, 27 July 2019

4th GB Meeting of IRTCBSF, Thiruvananthapuram, 30 July 2019

Release of cages and review of research activities of Mandapam Regional Centre of ICAR-CMFRI, 10-11 August 2019

NFDB meeting, Hyderabad, 07 August 2019

Meeting at Department of Biotechnology, New Delhi, 16 August 2019

Meeting with Space Applications Centre (SAC), Ahmedabad and follow-up meeting on acquisition of land for Office building for Veraval RC of ICAR-CMFRI, 22-23 August 2019

DBT-BIRAC meeting, New Delhi, 27 August 2019

Meeting with NABARD Officials, Mumbai, 01 October 2019

Seaweed Meeting conducted by NITI Aayog, Chennai, 12 October 2019

Visited sites of seaweed cultivation and also sites proposed for seaweed cultivation and held discussion on seaweed farming, Mandapam, Tamil Nadu, 13-14 October 2019

Meeting at Department of Biotechnology, New Delhi, 17-18 October 2019

Ornamental fish meeting conducted by Department of Fisheries, Govt. of Kerala, Kollam, 25 October 2019

Meeting for finalisation of AICRP/AINP Review Committee Recommendation chaired by DG, ICAR, New Delhi, 01 November 2019

Served as ICAR representative in the 4th GB Meeting of IRTC for Below Sea Level Farming chaired by the Chief Minister, Kerala, Thiruvananthapuram, 07 November 2019

Meeting at Department of Biotechnology, New Delhi, 08 November 2019

IMC Meeting at Mandapam Regional Centre of ICAR-CMFRI, Mandapam, 07 December 2019

Stakeholders meeting with State Fisheries Minister at Mangalore Research Centre of ICAR-CMFRI, Mangaluru, 13 December 2019

NICRA Meeting, New Delhi, 18 December 2019

CAS meeting, ASRB, New Delhi, 27 December 2019

Ajay D. Nakhawa

District Advisory Committee Meet related to fisheries management, Office of the Collector, Sindhudurg, 23 July 2019

District Advisory Committee Meet related to fisheries management at Office of the Collector, Ratnagiri, 11 September 2019

Resource person for the Training of Trainers (ToT) Programme on Remote Sensing and GIS Technology for Soil and Water Quality Mapping 2019, Sponsored by NFDB, 15 September 2019

Review meeting in connection with renovation of the Taraporevala Aquarium, Office of the Commissioner of Fisheries, Mumbai, 14 December 2019

Nagari Rajbhasa Karyvan Samitte, North Mumbai, 18 December 2019

Akhilesh, K. V.

Whale shark Conference, Ahmedabad, 14-15 April 2019

Anikuttan, K. K.

Meeting on hatchery certification organized by NFDB, Coastal Aquaculture Authority Head office, Chennai, 03 July 2019

Meeting chaired by Hon'ble Minister of Fisheries, Govt. of Kerala and presented the DPR prepared by CMFRI on establishment of marine ornamental fish breeding and rearing units in Kerala, ICAR-CMFRI, Kochi, 02 August 2019

Anulekshmi Chellappan

Consultative meeting at Fishery Survey of India (FSI), Sassoon Dock, Mumbai, 17 May 2019

134th meeting of Maharashtra Coastal Zone Management Authority (MCZMA), Secretariat, Mumbai, 24 May 2019

135th meeting of Maharashtra Coastal Zone Management Authority (MCZMA), Secretariat, Mumbai, 15 July 2019

Meeting with Executive Director, Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra and Additional Principal Chief Conservator of Forests, Mangrove Cell, Mumbai, 27 May and 30 May 2019

25th ICAR Regional Committee Meeting, Nagpur, 09-10 August 2019

Anulekshmi Chellappan, Akhilesh, K. V and Ajay D. Nakhawa

Discussion on "National Marine Fisheries (Regulation and Management) Bill, 2019", ICAR-CIFE, Mumbai, 13 September 2019

User Interaction Workshop with special emphasis to local needs and GEMINI (GAGAN Enabled Mariner's Instrument for Navigation and Information) organized by ESSO- INCOIS, Hyderabad in collaboration with Mumbai Research Centre of ICAR-CMFRI, 15 November 2019

Anulekshmi Chellappan, Akhilesh, K. V., Ajay D. Nakhawa and Khandagale, P. A.

Fisheries Improvement Project meet organized by Asian Fisheries Society, Indian Branch, Mangaluru in collaboration with Department of Fisheries Govt. of Maharashtra, Office of the Commissioner of Fisheries, Dept. of Fisheries, Govt. of Maharashtra, Taraporevala Aquarium, Mumbai, 14 December 2019

Anulekshmi Chellappan and Pawar, N. A.

Coastal road project meet headed by Shri. Pravin Pardeshi, IAS, Municipal Commissioner, Mumbai, 18 December 2019

Aswathy, N.

Resource person for Awareness programme on technical and financial aspects of Cage farming in the Block level bankers committee meeting organized by Vaikom Branch of SBI, Vaikom, 22 August 2019

Resource person for On-the Job training programme for VHSE students on "Economic performance of Aquaculture practices", ICAR-CMFRI, Kochi, 01 November 2019

Resource person for the Training programme on Cage farming for fish farmers, ICAR-CMFRI, Kochi, 05-07 November 2019

Meeting on impact assessment of ICAR technologies, National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi, 28 November 2019

Resource person for NFDB skill development programme, ICAR-CIFRI, Kochi, 12 December 2019

Chhandaprajnadarsini, E. M.

Stake holders' meeting coordinated by IOC, Nettukuppam, 10 December 2019

Dineshbabu, A. P.

Meeting on "Development of a Centralized Portal and Mobile Application for national wetland management" through NICRA project at Space Applications Centre (ISRO), Ahmadabad, 21 August 2019

Organized workshop for "Data analyses methodology finalisation" of BPT project, Chennai, 15-16 November and 20 November 2019

Eldho Varghese

Served as resource person for the training programme on "Statistical advances in designing agricultural experiments and data analysis" and delivered lecture on "Response surface designs and Design-Expert software", Centre of Advanced Faculty Training (CAFT), ICAR-IASRI, New Delhi, 19 July-08 August 2019

Eldho Varghese and Reshma Gills

8th International Conference on Agricultural Statistics (ICAS-VIII) sponsored by FAO, World Bank and USDA, New Delhi, 18-21 November 2019

Geetha Sasikumar, Purushottama, G. B. and Divya Vishwambharan

Organized Hands-on training on Oyster farming for Scheduled caste beneficiaries under Sub-Plan Scheme at Mulki, Dakshina Kannada, Karnataka, 21-26 October 2019

Jayakumar, R.

Review meeting of NFDB Project, NFDB, Hyderabad, 30 April 2019

Meeting on Draft National Mariculture Policy, ICAR-CMFRI, Kochi, 21 September 2019; 29-30 October 2019

Jayakumar, R. and Abdul Nazar, A. K.

"Knowledge sharing mission on marine fish species diversification" organized by USSEC, India, 29 July-03 August 2019

Visited M/s. MSR Aqua Hatchery, Kakinada, Andhra Pradesh in connection with technology transfer of marine finfish seed production under NFDB funded project, 27-28 December 2019

Jayakumar, R., Tamilmani, G., Sakthivel, M., Johnson, B., Anikuttan, K. K. and Sankar, M.

Cage farmers' meet under FIMSUL-II project' organized by State Fisheries Department at ICAR-CMFRI, Mandapam, 27 June 2019

Joe K. Kizhakudan, Jayakumar, R., Tamilmani, G., Sakthivel, M., Rameshkumar, P., Johnson, B., Anikuttan, K. K., Remya, L., Saravanan, R., Sankar, M., Rajkumar, M. and Thirumalaiselvan, S.

Resource persons for the Winter School on 'Mariculture Technologies: Principles and Practices to augment the seafood production in India', Mandapam RC of ICAR-CMFRI, 06-26 November 2019

Jayakumar, R. and Johnson, B

Meeting on Mariculture of Seaweeds at ICAR-CMFRI, Kochi, 11 July 2019

Swachhta Hi Seva activities organized by Mandapam RC of ICAR-CMFRI, Arichalmunai, 19 October 2019

Johnson, B.

'Brainstorming session on Green Rameswaram Project including the Alternate livelihood options for Fishermen', Rameswaram, 14 May 2019

Member, Regional Level Evaluation Committee for the selection of best village level co-management committee in Palk Bay Region, Ramanathapuram, 20 May 2019

Convenor of the Training programme on 'Seaweed farming' and 'Marine ornamental fish culture' for SMS (Fisheries), CMFRI-KVK, Kavaratti, Lakshadweep, 25-28 June 2019

Convenor of the Training programme on 'Sea Cage Farming of Cobia' under the Technology upgradation project for fishers in Ramanathapuram District, 28-30 June and 24-26 September 2019

International Conference and Exhibition on "Integrated Coastal Zone Management: Lessons Learned and Relevance for India", Chennai, 09 -10 July 2019,

Kick-off Workshop on Coastal Resilience at NIOT Chennai, 17 July 2019

Conference on 'Seaweed Cultivation and Open Sea Cage Culture' organized by Fisheries Department, Andaman and Nicobar Administration, Port Blair, 08-09 August 2019

Awareness programme on Mariculture Technologies under Scheduled Caste Sub-Plan (SCSP) Project at Mandapam Regional Centre of ICAR-CMFRI, 12 September 2019

International Coastal Cleanup Day organized by MSSRF at Sangumal, 21 September 2019

Coordinated the training programme as a part of 'International training-cum-workshop in fisheries and aquaculture' for AARDO member countries at Mandapam RC of ICAR-CMFRI, 19-20 October 2019

2nd workshop of the Technical Assistance on 'Coastal Resilience: Developing New and Innovative Approaches in India and Bangladesh along the Bay of Bengal', at NIOT campus, Chennai, 23 October 2019

Member, Research Advisory Committee to review the research projects sanctioned by Gulf of Mannar Biosphere Reserve Trust, Ramanathapuram, 13 November 2019

Convenor of the Training programme on 'Mariculture Technologies for Diversified Livelihood' under SCSP Project for fishers from Puthukudi Village, Thiruvadanai Taluk, Ramanathapuram District, Mandapam Regional Centre of ICAR-CMFRI, 19-21 November 2019

Coastal clean-up activity organized by *Kadal Osai* FM at Pamban, 21 November2019

General Body meeting organized by DHAN foundation, Uchipulli, 30 November 2019

Josileen Jose

Stakeholder workshop organized by Kerala Forum for Crustacean and Cephalopod Sustainability – Seafood Exporters Association of India – Kerala Region (SEAI-KFCCS), ICAR-CMFRI, Kochi, 07 May 2019

Workshop on 'Blue swimming crab (*Portunus pelagicus*) Fishery Improvement Project (FIP) and the Launch of Action Plan', Ramanathapuram, 21 August 2019

Served as resource person and delivered a lecture on "Crab resources and life history assessment" for the staff of Department of Fisheries (DoF), Kerala, organized by Fishery Resources Assessment Division of ICAR-CMFRI, Kochi, 19 October 2019

Joe K. Kizhakudan

Meeting with marine fisher leaders of Kancheepuram District; offcials of Dept. of Fisheries, Tamil Nadu and NGO representatives in connection with Marine Fisheries Draft Policy, Pudupattinam, 14 September 2019

Served as resource person and delivered invited lecture on "Coastal marine diversity and prospects on habitat restorations" in the DBT sponsored National Seminar on "Marine Natural Products and as Pharmaceutical Agents", Sathyabama University, Chennai, 17-18 September 2019

Conducted stakeholders and institution building meetings in 40 fishing villages for the consultancy projects on Artificial Reefs in Chennai, Thiruvallur, Kancheepuram, Thuthukudi, Thiruvarur, Pudukottai, Thanjavur, Tirunelveli and Ramnad, June-August 2019

Kajal Chakraborty

First meeting of the ICAR Metabolomics Research Group chaired by the DG, ICAR, 08 July 2019

Workshop and Review Meeting of "National Agriculture Innovation Fund (NAIF) Scheme", NASC Complex, New Delhi, 04-05 October 2019

Meeting of the Advisory Committee for the study on 'Mapping of Technologies for Value-Addition of Seaweeds' at Technology Information, Forecasting and Assessment Council, New Delhi, 23 December 2019

Kaladharan, P.

Served as Expert Member to the technical working group meeting of Local Biodiversity Strategy and Action Plan (LBSAP) of Kochi City organized by INTERACT-Bio, Kochi, 26 November 2019

Invited by the Seaweed Research and Utilization Association of India (SRUA I) to deliver Prof Krishnamurthy Endowment Lecture during the "National Conference on emerging trends in Algae", Palayamkottai, 28 November 2019

Kaladharan, P. and Johnson, B.

Meeting of NITI Aayog committee for promotion of seaweed cultivation in India and field visits at Chennai and Mandapam, 12-13 October 2019

Kapil S. Sukhdane

National Seminar Fish-Tech-19 "Fishery Waste Management: Challenges and Business Opportunities in Gujarat", Veraval, 11 July 2019

Laxmilatha, P.

Meeting with the Additional Chief Secretary / Project Director Ms. Meenakshi Rajagopal, IAS, to discuss about the modalities of a new project on artificial reefs under IFAD, Directorate of Rural Development and Panchayat Raj, Chennai, 29 April 2019

Regional Level Committee meeting conducted to select the best performing co-management Committee of the CDRRP-FIMSUL project, Office of the Joint Director of Fisheries (Regional), Chennai, 16 May 2019

Final Project Review Meeting of FIMSUL-II with World Bank Expert, Department of Fisheries, Government of Tamil Nadu, Chennai, 22 May 2019

International Day for Biological Diversity (IDB) 2019 and Thematic Exhibition on "Our Biodiversity, Our Food, Our Health", jointly organized by Ministry of Environment, Forests and Climate Change, National Biodiversity Authority (NBA) and Tamil Nadu State Biodiversity Board, Chennai, 22 May 2019

Meeting in connection with initiation of project on Artificial reefs to be deployed along Chennai, Tiruvallur and Kancheepuram, Directorate of Fisheries, Chennai, 09 September 2019

DBT Task Force meeting in connection with the DBT project on "Molecular taxonomy and phylogeny of Cones (Cone snails) and Strombs (Mollusca, Gastropoda) of the Indian coast" and presented the progress of the project. New Delhi, 17-18 October 2019

Stakeholder Consultation meeting on "Adopting best practices for Sustainable Fisheries Management" and presented "Marine Fisheries of Tamil Nadu: an overview" World Wide Fund for Nature, India, Chennai, 24 October 2019

Loveson Edward, L.

Meeting of government departments with Traffic Manager, Visakhapatnam Port Trust regarding vessel berthing and maintenance issues held at Visakhapatnam Port Trust office, Visakhapatnam, 07 June 2019

Workshop on "Understanding Arc GIS" conducted by the Geological Survey of India, Visakhapatnam, 20-23 November 2019

Consultative Group Meeting to review the activities of Visakhapatnam Zonal base of FSI, Visakhapatnam, 02 May 2019

Loveson Edward and Manas, H. M.

Stakeholders' consultation meet on 'Upscaling of Fisher Friendly Mobile Application and Promoting Fishery Advisory Services of INCOIS', Andhra University, Visakhapatnam, 27 June 2019

Maheswarudu, G., Dineshbabu, A. P., Sarada, P. T., Lakshmi Pillai, S., Rekha Devi Chakraborty, Saleela, K. N., Gyanranjan Dash, Ratheesh kumar, R. and Rajkumar, M.

Workshop on "Implications of recruitment dynamics of penaeid prawns for fisheries management", ICAR-CMFRI, Kochi, 15-20 July 2019

Manas, H. M.

Workshop on "Refinement of Marine Fisheries Management in Andhra Pradesh", NETFISH-MPEDA, Kakinada, 20 August 2019

Margaret Muthu Rathinam and Chhandaprajnadarsini, E. M.

Training programme on "Application of advanced methods and tools to improve estimation of marine fish landings of Tamil Nadu with increased granularity and precision" under the FIMSUL project, Component III, ICAR-CMFRI, Chennai, 06-10 May 2019

Training workshop on "Spoken Hindi" as a part of implementation of official language, ICAR-CMFRI, Chennai, 10 July 2019

"*Swachhta hi seva*" rally at Pattinapakkam in connection with Swachh Bharat Abhiyan, Chennai, 19 September 2019

Muktha, M., Loveson Edward, L. and Jasmin, F.

Discussion on "Draft of Marine Fisheries (Regulation and Management) Bill, 2019", conducted by Dept. of Fisheries, Govt. of Andhra Pradesh, Visakhapatnam, 09 August 2019

Muktha, M., Raju, S. S., Indira Divipala, Manas, H. M., Jasmin, F., Loveson Edward, L. and Pralaya Ranjan Behera

Pre-survey awareness meet on "Shark and ray non-fin commodities", Visakhapatnam, 30 September 2019

Narayankumar, R.

Workshop on "Role of S&T institutions in the Promotion of Entrepreneurship and Sustainable Livelihood in Rural Areas through Fisheries Sector" organized by National Institute of Rural Development and Panchayati Raj (NIRDPR) and National Fisheries Development Board (NFDB), Hyderabad, 14 May 2019

International Day for Biological Diversity 2019 Ministry of Environment & Forests and Climate Change, Chennai, 22 May 2019

Expert Consultation and Exposure Programme on Fisheries Value Chain to develop a fishery value chain manual for Myanmar District organized by Youth Welfare Organization, Visakhapatnam, 03-07 September 2019

Stakeholders' meeting to discuss The National Marine Fisheries (Regulation and Management) Bill, 2019, Chennai, 16 September 2019

Review Meeting with World Bank Mission Team of FIMSUL organized by the Department of Fisheries, Government of Tamil Nadu, Chennai, 18 September 2019

Stakeholders' Workshop for the Health & Sanitation, Transport and Coastal Fisheries Sector organized by the Fisheries Department, Tamil Nadu and served as a Panelist in the Session on Protection Policies for fishing women in Chennai, organized by the Women's Indian Association (WIA), Chennai, 23 October 2019

Workshop on "Economic development and social transformation through GPDP in coastal states and union territories" organized by National Institute of Rural Development and Panchayat Raj (NIRDPR), Chennai, 30-31 October 2019

Stakeholder Meeting for Marine and coastal biodiversity protection and conservation in Ennore Area under Indian Oil Corporation Limited (Corporate Social Responsibility), Chennai, 10 December 2019

STTP Workshop on "Procedures for patent drafting", Annamalai University, Chidambaram, 13 December 2019

Narayankumar, R., Margaret Muthu Rathinam and Chhandaprajnadarsini, E. M.

Training programme on "Application of advanced methods and tools to improve estimation of marine fish landings of Tamil Nadu with increased granularity and precision" as a part of FIMSUL project component-II, 06 -10 May 2019

Nilesh A. Pawar

Brainstorming session organized by CHME Society's Bhonsala Military College (BMC) and Kanhoji Angre Maritime Research Institute (KAMRI) on "Challenges of Coastal Community and their role in nation building", Dadar, 19 September 2019

Resource person for the one-day National Workshop on "Aquatic Animal Diseases in Chhattisgarh" under National Surveillance Programme for Aquatic Animal Disease (NSPAAD), College of Fisheries, Kawardha, 30 September 2019

Resource person for the NFDB sponsored trainers training programme on "Cage and Pen Culture" organized by ICAR-CIFE, Mumbai, 04-08 November 2019

Winter School on "Responsible fishing: Recent advances in resource and energy conservation", ICAR-CIFT, Kochi, 21 November-11 December 2019

Prathibha Rohit

Review meeting of NFDB funded projects, NFDB, Hyderabad, 30 April 2019

3rd IOTC preparatory meeting, Chennai, 09 May 2019

23rd Session of IOTC, Hyderabad, 16-21 June 2019

Meeting of Fish meal plant owners, former Fisheries Minister, Government of Karnataka and officials of College of Fisheries, Mangaluru at College of Fisheries, Mangaluru, 13 August 2019

IOTC review meeting organized by the Department of Fisheries, Govt. of India, New Delhi, 02-03 September 2019

ICZMP meeting, Karwar, 22 October 2019

World Bank aided ICZMP phase II meeting at Bengaluru, 25 October 2019

Prathibha Rohit, Laxmilatha, P. and Jayakumar, R.

26th meeting of the ICAR Regional Committee, Indian Institute of Horticulture Research (IIHR), Bangaluru, 06-07 September 2019

Prathibha Rohit, Abdussamad, E. M., Josileen Jose, Margaret Muthu Rathinam, Rajesh, K. M., Aswathy, N., Anulekshmi Chellappan, Ajay D. Nakhawa, Manas, H. M. and Vinothkumar, R.

National Symposium on "The Enigmatic Oil Sardine", ICAR-CMFRI, Kochi, 06 August 2019

Workshop on "Large Pelagics" ICAR-CMFRI, Kochi, 07-08 August 2019

Prathibha Rohit, Dineshbabu, A. P., Sujitha Thomas, Geetha Sasikumar, Rajesh, K. M., Bindu Sulochanan, Purushittama, G. B. and Divya Viswambharan

Hindi workshop on "General grammar and usage of Hindi language in daily functioning of office matters", 21 September 2019

Stakeholders meeting organized by Mangalore Research Centre of ICAR-CMFRI, Mangaluru, 13 December 2019

Prathibha Rohit, Dineshbabu, A. P., Sujitha Thomas and Rajesh, K. M.

Meeting to review the progress of NFDB project at Mangalore Research Centre of CMFRI, Mangaluru, 17 August 2019

Prathibha Rohit, Dineshbabu, A. P. and Rajesh, K. M.

Marine Fisheries Improvement Project launching programme organized by Asian Fisheries Society, Indian Branch and Department of Fisheries, Govt. of Karnataka, Mangaluru, 25 July 2019

Prathibha Rohit and Dineshbabu, A. P.

Integrated Coastal Zone Management (ICZM) project Phase-II meeting conducted by Department of Forests, Ecology and Environment, Mangaluru, 13 May 2019

Meeting on "Data requirement for fisheries sector" convened by NFDB, Hyderabad, 01 August 2019

Prathibha Rohit and Sujitha Thomas

Meeting on "Marine Wildlife Conservation" at Department of Forests & Wild life, Mangaluru, 18 October 2019

Prathibha Rohit and Rajesh, K. M.

Resource persons for the Training programme for officials of the Department of Fisheries, UT of Lakshadweep, Kavaratti, 01-03 May 2019

Purushottama, G. B.

Training programme on "Emotional Intelligence at workplace for Scientists and Technologists" at Centre for Organization Development, Hyderabad, 05-09 August 2019

Rajkumar, M.

Working Committee Meeting for "Fishery improvement project for flower shrimp", Mandapam, 24 May 2019

Fourth Working Committee of "Fishery improvement programme for flower shrimp in Palk bay region", MSSRF, Thangachimadam, 15 October 2019

Raju, S. S.

Orientation-cum-Awareness meet on "Fish Market Price and Information System (FMPIS)", Vijayawada, 18 July 2019

Ramkumar, S. and Ajay D. Nakhawa

Cetacean bycatch Workshop hosted by WWF-India (Goa office), Goa, 08-10 July 2019

Remya, L. and Vinothkumar, R.

Workshop cum awareness programme on "Oceanic fishery resources of the southeast coast of India and responsible fishing" organized by Fishery Survey of India (FSI), Mandapam, 18 October 2019

Reshma Gills

Focus group discussion with experts at National Skill Development Agency (NSDA), New Delhi, 20 November 2019

Resource person for Satellite workshop on 'Vocational Education and Employability' at Govt. FHSS, Kaipamangalam, Thrissur, 06 December 2019

Sakthivel, M.

DST sponsored Training programme on "Science administration and research management" at Administrative Staff College of India, Hyderabad, 01 -12 July 2019

Sakthivel, M., Johnson, B. and Anikuttan, K. K.

Meeting of the core team on preparation of the draft guidelines on "Green Certification of Marine Ornamentals" at ICAR-CMFRI, Kochi, 18-19 July 2019

Sankar, M.

NFDB sponsored Training programme on "Marine finfish seed rearing in ponds" organized by Tamil Nadu Fisheries Department, Ramanathapuram, 24 September 2019

Santosh N. Bhendekar

Hands on training on "Molluscan Hatchery" at Vizhinjam Research Centre of ICAR-CMFRI, Thiruvananthapuram, 09-12 July 2019

District Advisory Committee Meet related to fisheries management at Office of the Collector, Sindhudurg, 20 August 2019

Resource person for the NFDB sponsored training programme on "Remote sensing and GIS technology for Soil and water quality Mapping" organized by ICAR-CIFE, Mumbai, 16-20 September 2019

Saravanan, R.

World Fisheries Day campaign for fisher folks conducted by State Fisheries Department, Govt. of Tamil Nadu, Devipattinam, 21 November 2019

Sekar Megarajan

Conference on "Seaweed Cultivation and Open Sea Cage Culture", Port Blair, 08-09 August 2019

Radio programme on World Jellyfish Day organized by Kadal Osai FM at Pamban, 03 November 2019

Shelton Padua

Inventor, User and Industry Meet on Coral Reef Monitoring Boat (C-Bot), NIO, Goa, 27 September 2019

Resource person for the 'On-Job Training for VHSC Students' at ICAR-CMFRI, Kochi, 25 October 2019

Training on High Performance Computing System, ICAR-CMFRI, 21 December 2019

Shinoj, P.

National Hindi Seminar on 'Contribution of Fisheries in Indian Economy' at ICAR-CIFT, Kochi, 11 July 2019

Shubhadeep Ghosh

Mid-Term Review, ICAR-CIFRI, Barrackpore, 12 June 2019

Stakeholder consultation meeting on "Adopting best practices for Sustainable Fisheries Management", Vijayawada, 19 June 2019

Shubhadeep Ghosh, Raju, S. S., Ritesh Ranjan, Biji Xavier, Muktha, M., Loveson Edward, Pralaya Ranjan Behera, Sekar Megarajan, Indira Divipala, Jasmin, F. and Manas, H. M.

Stakeholder workshop, Visakhapatnam RC of ICAR-CMFRI, 21 May 2019

Shubhadeep Ghosh, Loveson Edward, L. and Manas, H. M.

"Sustain Fish 2019" awareness workshop on "Harvest and post-harvest intervention for mainstreaming biodiversity conservation into fisheries sector of East Godavari Riverine and Estuarine Ecosystems", Visakhapatnam RC of ICAR-CIFT, Visakhapatnam, 13 November 2019

Shubhadeep Ghosh, Narayankumar, R., Ritesh Ranjan, Loveson Edward, L., Pralaya Ranjan Behera and Manas, H. M.

Stakeholders' meeting convened by the Dept. of Fisheries, Govt. of Andhra Pradesh and chaired by Shri. Giriraj Singh, Honourable Union Minister for Fisheries, Animal Husbandry and Dairying, Visakhapatnam, 06 September 2019

Shubhadeep Ghosh, Raju, S. S., Ritesh Ranjan, Biji Xavier, Muktha, M., Loveson Edward, L., Pralaya Ranjan Behera, Sekar Megarajan, Indira Divipala, Jasmin, F. and Manas, H. M.

National Hindi Seminar "*Harith Mathsyaki 2019*–Opportunities and challenges for sustainable development of Indian fisheries", Visakhapatnam RC of ICAR-CIFT, Visakhapatnam, 30 July 2019

Shyam S. Salim

Meeting with local fishers and traders of sharks and rays under "FAO CMFRI Collaborative Project on Sharks & Rays Non-fin Commodities" at Calicut, 24 September 2019

Resource person for the Winter School on "Precision Fish Farming: Automation Principles and Technological Solution for Sustainable Aquaculture Production and Productivity at ICAR-CIFE, Mumbai, 07 December 2019

Shoba Joe Kizhakudan

Convened stakeholders' meeting on "Fishery and trade of sharks and rays" at Madras Research Centre of ICAR-CMFRI, 25 September 2019

Regional Consultation to discuss 'Development of a Regional Plan of Action to Combat IUU Fishing', Chennai,14-15 October 2019

Sujitha Thomas, Purushottama, G. B. and Divya Vishwambharan

Awareness programme on "Shark conservation and trade" at Coastal Security Police station, Mangaluru, 20 September 2019

Sumithra, T. G. and Reshma, K. J.

National workshop on "Biostatistics for health professionals", Medical College, Kolancheri, 04-05 October 2019

National Seminar on "AMR in Indian Fisheries: Measures of Mitigation", ICAR-CIFT, Kochi, 07-08 November 2019

Vijayagopal, P.

Resource person for the Training to Department of Fisheries Officials, Govt. of Kerala, 13 May 2019

Resource person for the Training programme on "Pearl spot seed production technology" for farmers at ICAR-CMFRI, Kochi 02-03 July 2019

Resource person in the Training for VHSE aquaculture students, GVHSS, Arthungal and Njarakkal, 19 September 2019

Resource person for the lecture on "Fish nutrition and feed technology" for B.Sc. Zoology students of Cochin College, 05 October 2019

Resource person for the lecture on "Fish nutrition and feed technology" in AARDO International training programme, ICAR-CMFRI, Kochi, 28 October 2019

Vijayagopal, P., Narayankumar, R., Joe K. Kizhakudan, Asha, P. S., Jayakumar, R., Biji Xavier, Sekar Megarajan, Anikuttan. K. K. and Vinothkumar, R.

International Sumposium Asian-Pacific Aquaculture 2019 (APA'19) organized by World Aquaculture Society–Asia Pacific Chapter, Chennai, 19 June 2019

Vinothkumar, R.

Radio talk on "Gulf of Mannar and its Fishing methods" Madurai Regional station of All India Radio, 28 August 2019

FIMSUL District level Co-Management committee meeting organized by Tamil Nadu State Fisheries Department, Ramanathapuram, 30 August 2019

FIMSUL District level co-management committee meeting organized by Tamil Nadu State Fisheries Department, Mallipattinam, 14 September 2019

Stakeholders' meeting on Draft National Marine Fisheries Policy organized by Tamil Nadu State Fisheries Department, Mallipattinam, 14 September 2019

Stakeholders' meeting on Draft National Marine Fisheries Policy organized by Tamil Nadu State Fisheries Department, Kottaipattinam, 17 September 2019

Vipinkumar, V. P.

Resource person for session on 'Motivational Skills' for Fisheries Inspectors of Kerala State Fisheries Department, NIFAM, Kadungallur 05 April 2019

Resource person for session on "Motivation for personal effectiveness" for Fisheries development Officers organized by SAF, 17 and 24 May 2019; 25 October 2019

Consultation Meeting on "Biodiversity beyond National Jurisdiction" organized by CMLRE, Kochi, 01-02 July 2019

Organized orientation training on "Pearlspot seed production" for SHGs of SC fisher folk at Vallarpadam, 18 July 2019; 28-29 October 2019

Organized orientation training and demonstration on "Cage farming" for SHGs of SC fisher folk at Kambithazham, Kuzhippilli and Edavanakkad, 13 August; 19-20 September 2019

Organized On–the-job Training programme' on "Advances in Fisheries and Aquaculture techniques" for students of VHSE Schools at Narakkal and Arthungal, ICAR-CMFRI, 18 September-01 October 2019

Organized 'On–the-Job Training programme on "Recent Technological Advances in Aquaculture" for students of VHSE schools at Kadamakkudy and Kaipamanagalam, ICAR-CMFRI, Kochi, 23 October- 02 November 2019

"Swasraya Bharath: Indian Science Congress Expo 2020" organized by Swadeshi Science Movement at Marie Drive, Kochi, 23-26 November 2019

Organized orientation training and demonstration on "Fish fertilizer production" for SHGs of SC fisher folk at Cherai, 28 November and 20 December 2019

Vipinkumar, V. P., Aswathy, N. and Sanal Ebaneezer

International Conference on "Aquatic Resources and Blue Economy (AQUABE 2019)" organized by Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, 28-30 November 2019

Zacharia, P. U.

Meeting of the Cochin Fisheries Harbour Advisory Committee at Cochin Port trust, 29 May and 05 December 2019

Meeting of the Board of studies, College of Fisheries, KUFOS, Panangad, 07 August 2019

Stakeholder awareness meeting as part of international whale shark day, Ponnani Fisheries Harbour, 30 August 2019

7th NICRA Annual Review Meeting at NASC, New Delhi, 17-18 December 2019

Zacharia, P. U., Kaladharan, P., Dineshbabu, A. P., Sujitha Thomas, Santosh N. Bhendekar, Chhandaprajnadarsini, E. M. and Thirumalaiselvan, S.

Handing over and demonstration of Beta version of National Wetland Mobile App and Website developed by SAC, Ahmadabad to ICAR-CMFRI-NICRA at ICAR, CMFRI, Kochi, 30 September 2019

Zacharia, P. U., Mohamed, K. S., Sathianandan, T. V., Lakshmi Pillai, S., Ganga, U., Najmudeen, T. M., Somy Kuriakose, Mini, K. G., Shyam S. Salim, Rekha Devi Chakraborty, Eldho Varghese and Shelton Padua

3rd Lenfest EBFM Meeting, ICAR-CMFRI, Kochi, 29 October-01 November 2019

Zacharia, P. U., Mohamed, K. S., Kripa, V., Sathianandan, T. V., Joshi, K. K., Prathibha Rohit, Maheswarudu, G., Josileen Jose, Ramachandran, C., Abdussamad, E. M., Molly Varghese, Lakshmi Pillai, S., Rekha J. Nair, Najmudeen, T. M., Venkatesan, V., Mini, K. G., Shinoj, P., Eldho Varghese, Vlidya, R. and Livi Wilson

Stakeholder workshop in connection with the project "Resource Assessment and Management Framework for Sustainable Marine Fisheries of Kerala", 07 June 2019

Zacharia, P. U., Rekha J. Nair and Najmudeen, T. M.

Stakeholder meet on "Shark and Ray non-fin commodities", ICAR-CMFRI, Kochi, 28 September 2019

Zacharia, P. U., Shoba Joe Kizhakudan, Manojkumar, P. P., Sujitha Thomas, Rekha J. Nair, Najmudeen, T. M., Shyam S. Salim, Purushottama, G. B., Muktha, M., Akhilesh, K. V., Swatipriyanka Sen Dash, Subal Kumar Roul, Rajesh Kumar Pradhan, Mahesh, V., Shinoj, P., Remya, L. and Ambarish P. Gop

FAO-CMFRI Global Expert Meeting on "Collection and reporting of Use, Market and Market Chain Information for Shark and Ray non-fin commodities", ICAR-CMFRI, Kochi, 24-27 July 2019

Zacharia, P. U. and Sujitha Thomas

Meeting for signing MOU regarding project formulation on "Development of a Centralized Portal and Mobile Application for national wetland management" between ICAR-CMFRI and ISRO at SAC Ahmedabad, 08-09 April 2019

Zacharia, P. U., Sujitha Thomas, Sobha Joe Kizhakudan, Shyam S. Salim, Muktha, M., Akhilesh, K. V. and Swatipriyanka Sen Dash

Report finalisation workshop of "Elasmobranch Value Chain Survey", ICAR-CMFRI, Kochi, 01-03 April 2019

Deputation Abroad

Dr. A. Gopalakrishnan, Director

52nd Council Meeting of the Asian Fisheries Society (AFS), 35th Anniversary Meeting of the Asian Fisheries Society and the 12th Asian Fisheries and Aquaculture Forum (12AFAF), Iloilo City, Philippines. 08-12 April 2019

Aswathy, N.

12th Asian Fisheries and Aquaculture Forum (12AFAF), Iloilo City, Philippines. 08-12 April 2019

Rajesh, K. M.

FAO International Symposium on "Fisheries Sustainability: Strengthening the Science-Policy Nexus". Food and Agricultural Organization (FAO), Rome, Italy, 18-21 November 2019.

Shinoj, P.

Regional Consultative Workshop on 'Strengthening Governance of Aquaculture for Sustainable Development in Asia and Related Country Review Studies' organized by FAO/NACA, Bangkok, Thailand, 05-07 November 2019

Shoba Joe Kizhakudan

Capacity Development Workshop on Stock Status Assessment and Estimation of SDG Indicator 14.4.1 for the Asia Pacific Region, Food and Agriculture Organization (FAO) and South East Asian Fisheries Development Centre (SEAFDEC), Bangkok, Thailand, 02-04 October 2019.

Somy Kuriakose, Najmudeen, T. M. and Eldho Varghese

Training in Models of Intermediate Complexity for Ecosystem assessments (MICE), CSIRO Laboratories, Hobart, Tasmania, Australia, 29 April-10 May 2019

Shubhadeep Ghosh and Sekar Megarajan

"Marine Fisheries International Program 2019", Shanghai Ocean University, China, 06-31 May 2019

Shyam S. Salim

Scoping Workshop Meet in developing overflow projects and to showcase the different climate hotspots case studies to the different stakeholders, University of Sao Paulo, Brazil, 24-31 May 2019

Panelist of the session on "Fisheries management in the face of changing climate" in the International Symposium on "Fisheries Sustainability: Strengthening the Science-Policy Nexus", FAO Headquarters, Rome, Italy, 18-21 November 2019

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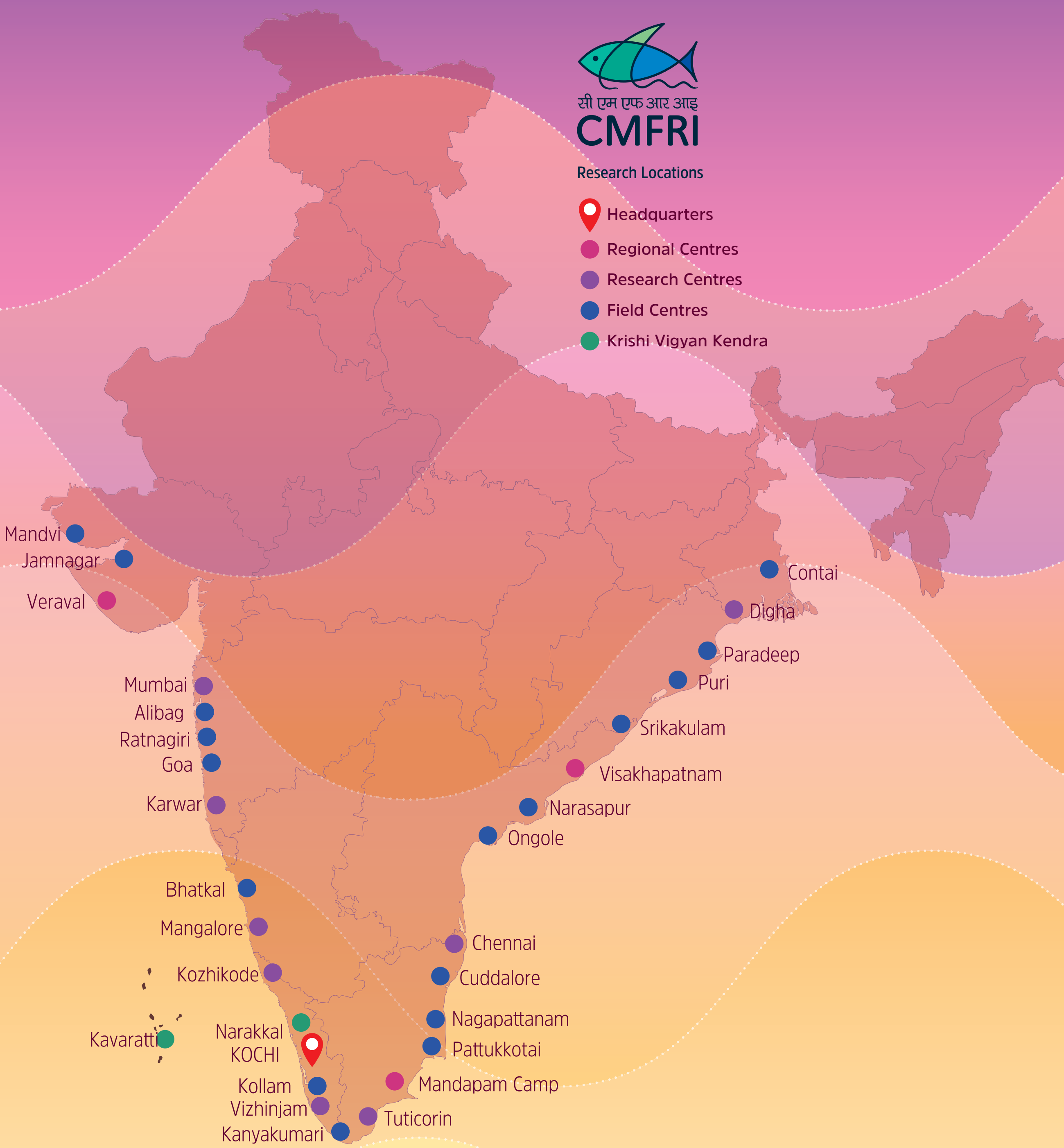

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